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ATOMS[1]

By Dr. PAUL R. HEYL

PHYSICIST, NATIONAL BUREAU OF STANDARDS

MATTER is at once the most familiar and the most puzzling thing in the universe. Many speculations as to its ultimate nature have been made and discarded. The twentieth century, apparently despairing of explaining it, has explained it away by making it merely another aspect of that Protean concept, energy. Yet though we can not answer the question "What is matter?" we may still find it profitable to consider its physical structure, for this is something about which we have been able to learn much by experiment.

Two opposite views of the structure of matter are possible, and both have been held since ancient times. We need know nothing of the ultimate nature of matter to recognize that it must be either as continuous as it appears to be or else discontinuous, but of so fine a grain as to elude our observation. In that Great Age of Greece centering around 400 B.C. we find philosophers holding both theories of the structure of matter. The continuous theory was maintained by Anaxagoras and Aristotle, while the existence of atoms was upheld by Democritus and Epicurus.

The antiquity of the atomic concept is sometimes cited as an instance of the keenness of thought of the ancients, much as if they had made by the unaided intellect a discovery which in modern times has received much experimental attention. We must be careful, however, not to over-rate the ancients in this respect. Neither theory as held by them had anything which we to-day would call an experimental basis; both were equally pure speculation. It does not require an exceptional intellect to formulate two alternatives when there is no evidence for or against either. The modern crank, who ignores or is ignorant of experimental facts, can spin out of his inner consciousness hypotheses in profusion. Ancient science is frequently disappointing. The ancient philosophers guessed at the causes of phenomena but often stopped there. We of to-day guess also, but we check our guesses by experiment.

It can not be urged that experiment was altogether impracticable for the ancients. There may be mentioned two accepted doctrines of antiquity, the falsity of which might have been shown by experiments simple enough to be possible at any time or place, yet which no one seems to have thought of carrying out.

The first of these is the dictum of Aristotle that heavy bodies fall with speeds proportional to their weights. It is remarkable that with the exception of one fruitless and soon forgotten criticism of this dictum, made by a philosopher of the sixth century A.D.,[2] there is no record of any other skeptic until the time of

[1] Publication approved by the director of the Bureau of Standards of the U. S. Department of Commerce.

[2] John Philoponus, cited by Heidel: "The Heroic Age of Science," p. 187. Baltimore: Williams and Wilkins Company, 1933.

Galileo, two thousand years after Aristotle.

The second of these erroneous notions is embalmed in our word "crystal," which comes from a Greek word meaning ice. The ancients knew quartz in the form of rock crystal, but in their experience this mineral was found only in certain elevated mountain regions where the cold winter was intense and long continued. They believed it to be water which had been permanently frozen by this extreme cold. Apparently no one ever thought of leaving a vessel of water to pass the winter in these regions—or was willing to take the trouble.

While perhaps no particular credit is to be assigned to those ancient philosophers who suggested that matter was discontinuous in structure, the idea was thus placed on record, to be taken up again centuries later. But all through the Middle Ages, due to the ascendency and authority of Aristotle, the continuous theory was supreme. The discontinuous or atomic theory is to-day so familiar and generally taken for granted that it is difficult to imagine any other hypothesis as worthy of serious consideration, yet the opposite theory continued to have its advocates down to quite recent years. Among these may be mentioned T. Sterry Hunt, the chemist and geologist, who died in 1892, and the still better known name of Ernst Mach, of Vienna, who lived until 1916. The atomic theory, though of a respectable antiquity, has had a long struggle for acceptance. Its final victory presupposes some rather cogent experimental evidence in its favor, which it may be of interest to set forth and consider. Of this evidence we may distinguish four independent lines which we shall discuss in their historical order.

The atomic theory of matter began to regain favor with the birth and growth of experimental science after the revival of learning. Perhaps the Roman poet Lucretius, who shared the renewed interest of the learned world of the Renaissance in the classic writers, had a share in the revival of the atomic theory, for he was an earnest upholder of this view. But the principal reason for the revival of the atomic theory was general rather than precise and specific. With an increasing knowledge of the phenomena of nature many things were found to be more simply explainable on the discontinuous theory. The expansibility of gases and the great change in volume from water to steam stretched the continuous theory to the breaking point, while on the alternative theory it was necessary merely to suppose that the particles of steam were farther apart than those of water. Boyle and Newton believed in the existence of atoms though they used the term rather loosely, and in many cases where we would say "molecule." The modern distinction between atoms and molecules was not clearly established until the middle of the nineteenth century.

This general line of reasoning, of course, did not satisfy everybody. There were, as we have said, skeptics throughout the nineteenth century. But the atomic concept by the year 1805 had so far reestablished itself as good form that Dr. Thomas Young offered no apology for attempting to determine the size of a molecule.

The second line of evidence for the existence of molecules and atoms is of a chemical nature. It was put forward by Dalton in the early years of the nineteenth century. So great was the impetus which Dalton gave the subject that he has been called "The Father of the Atomic Theory." What he did to warrant that title was something characteristic of the nineteenth century: he made the theory quantitative.

Dalton introduced the idea of atomic weights, a definite weight for the atom of each element. He appears, on the evidence of his manuscript note books,[3]

[3] Roscoe and Harden, "A New View of the Origin of Dalton's Atomic Theory," Macmillan and Company, 1896.

to have been led to this by physical rather than chemical considerations, such as the diffusion of gases and the varying solubility of different gases in water. By a study of these phenomena he was led to the concept of a difference in the size of the molecules of various gases. From definite sizes it was an easy step to the idea of definite weights characteristic of each substance. This explained much with regard to quantitative chemical combination, and appears to have been the origin of his laws of definite and multiple proportions.

These laws of Dalton, whatever may have been their origin, rest securely upon the results of chemical analysis. They follow at once from the assumption of the combination of atoms with atoms, while on the continuous theory there is no simple explanation of the results of experiment. As Dalton himself said: "The doctrine of definite proportions appears mysterious unless we accept the atomic hypothesis." And again: "It appears like the mystical ratios of Kepler, which Newton so happily elucidated." With the later development of analytical technique, especially at the hands of Berzelius and of Stas, the atomic theory reached a high degree of probability.

In the year 1827 there was made a discovery which was destined to furnish a third independent line of evidence for the reality of molecules. The full development of this evidence, theoretical and experimental, required eighty years for completion. In 1827 Robert Brown, a British botanist, was investigating the pollenation of plants, and had occasion to observe under the microscope minute grains of pollen suspended in water. He noticed that even under the best observing conditions these grains were never at rest, but vibrated slightly and irregularly about a mean position. This phenomenon has since been known as the Brownian motion.

[4] *Phil. Mag.*, 4: p. 161, September, 1828; 6: p. 161, September, 1829.

Brown's original paper[4] is most interesting reading. It reveals the working of a mind essentially logical and scientific, albeit hampered in one respect by a traditional intellectual fetter. Brown first satisfied himself that the motion was not due to the vibration of his apparatus nor to convection currents nor to evaporation of the liquid. He observed the motion in drops of water suspended in oil, which completely prevented evaporation, and found that the motion continued for many days, while differences of temperature should have equalized themselves in a comparatively brief time.

Among these grains of pollen Brown noticed smaller particles of a roughly spherical form which showed a more brisk vibration than the larger grains. These smaller particles he called "active molecules."

There was current in biological circles at that time a theory that there was an ultimate element or atom of life, an idea which some dozen years later was merged into the concept of the newly discovered cell as the biological unit. Brown appears to have believed at first that in his active molecules he had found these atoms of life. He had satisfied himself that the motion was not due to extraneous causes such as vibration or convection currents, but appeared to be a characteristic of the particles themselves, and as the particles were derived from a living plant it was but natural that he should have reached the conclusion that their motion was in some way due to life.

To check this conclusion he killed a plant by steeping it for several days in alcohol. Much to his surprise he found that he could extract from this dead plant active molecules of apparently undiminished vitality. It then became of importance to determine how long these particles would retain their vitality after the death of the plant.

From a herbarium Brown obtained a specimen which had been twenty years in the collection, and from this he ob-

tained active molecules. Another specimen which had been in the collection for a century gave the same result. It was then obviously necessary to work with material of geological age, and specimens of lignite and bituminous coal were tried, in each of which active molecules were found. Surprise was added to surprise when Brown found that the London soot seemed to be composed almost entirely of active molecules, though it had but recently been through the fire.

Brown their tried a piece of petrified wood. He knew that in this substance the wood fiber had been entirely replaced by silica, but he thought it possible that some active molecules might have lingered behind. He found, in fact active molecules in surprising abundance.

This led Brown to experiment with materials which, as far as was known, had never been living, such as specimens of British granite, and again the active molecules were in evidence. Finally, to obtain a specimen of undoubted antiquity, he tried a chip taken from the Sphinx!

This test was not as childish as it may seem to-day. In 1827, and indeed for many years after, the whole of Western Christendom, learned and unlearned, was still under the spell of Archbishop Usher's chronology, which assigned to the Creation the date 4004 B.C. To question this was in those days no laughing matter.

The universal presence of these active molecules was a mystery which Brown did not attempt to explain. A later writer[5] (1863) says that Brown was of the opinion that these particles of elementary life, existing everywhere, might bridge over the gap between the living and the non-living, the idea apparently being that in some substances these active molecules lay dormant but eternal, while in others they developed into living organisms.

Brown's discovery attracted but little attention at the time. It was generally thought that this motion must be in some way similar to the dancing of motes in a sunbeam, in spite of the care that Brown had taken to eliminate the explanation of convection currents. It was not until 1863, when the concept of atoms and molecules had become well established, and a beginning had been made in the kinetic theory of heat, that Wiener[6] suggested the explanation now generally received—that the motion of these particles was the result of the impacts of the molecules of water, much as a swiftly moving bullet may produce a slight motion in a much heavier cannon ball.

Wiener's suggestion attracted in its turn but little attention. Some fifteen years later Delsaulx and Carbonnelle[7] again put forward the same explanation with an important addition. It was apparent to Carbonnelle that the impacts of the water molecules would occur in such rapid succession that they could not produce any perceptible disturbance of a large particle, the successive impacts nearly cancelling out on the whole. But Carbonnelle pointed out that if the surface of the suspended particle was small enough it might be that the irregularities would no longer compensate; that there would be a perceptible resultant which would change continually in intensity and direction. In consequence, the smaller the particle the more brisk should be its vibration. It will be remembered that this is just what Brown observed with the pollen grains and the smaller particles which he called active molecules.

These suggestions seem to have attracted as little attention as that of Wiener, but in 1888 Gouy[8] published an account of experiments on this subject which for some reason attracted wide attention. From this time the Brownian

[5] Wiener, *Pogg. Ann.*, 118: p. 79, 1863.

[6] *Ibid.*

[7] See an article by Thirion, *Revue des Questions scientifiques*, January, 1909.

[8] Gouy, *Journal de Physique*, 7: p. 561, 1888; *Comptes rendus*, 109: p. 102, 1889.

movement was recognized as an important physical problem.

The next important step toward its explanation came with the early years of the twentieth century, and with it were connected the names of Einstein, Smoluchowski and Perrin.[9] The contributions of the first two were theoretical, while that of Perrin was largely experimental and furnished confirmation of the theories of the others.

One of the most remarkable observed facts in connection with the Brownian movement was that the rapidity of the agitation of a particle seemed to depend upon its size rather than its mass. Equally sized particles of metallic dust, droplets of oil and even air bubbles, in the opinion of good observers, showed very nearly the same agitation. It is likely that this observed fact, so contrary to what might be expected, had much to do with the slowness to accept the hypothesis of molecular collisions as the cause of the Brownian movement, for it is obvious that the impact of a bullet upon a cannon ball or a croquet ball should produce a greater velocity in the latter. But it is to be remembered that in the Brownian motion we observe not the consequences of individual impacts, but the resultant of many impacts. Einstein and Smoluchowski by independent paths arrived at formulas almost identical, which indicated that the resultant displacement of a very small suspended particle is independent of its mass, but varies inversely as its radius. Moreover, their formulas, as well as that of Perrin, led to the conclusion that the ultimate distribution of the particles in an emulsion in equilibrium under the joint influence of gravity and molecular impacts should follow an exponential law similar to that of the density of the atmosphere as a function of the height.

Perrin saw in this an opportunity for a crucial experiment, and with consummate skill carried it through to a successful conclusion.

In addition, the formulas of Einstein and Smoluchowski involved Avogadro's constant, the number of molecules in a gram-molecule, as a function of quantities measurable in a given emulsion, such as the density of the liquid and that of the suspended particles, the radius of these particles and the exponential constant of vertical distribution. Perrin's experiments gave a value for Avogadro's constant in good agreement with that given by other well-known methods, none of which involve the suppositions of the Brownian movement.

Largely as a result of Perrin's experimental work it has become clear to us that a suspended particle showing the Brownian motion is to be regarded simply as a big molecule. Below such particles we have colloidal suspensions, from which it is an easy step to such immense but undoubted molecules as those of Congo red, with a molecular weight of several hundred. Between a molecule and a particle there is no point where we can draw a sharp line of distinction. The kinetic theory of gases can be extended, as Van't Hoff showed, to the molecules of dilute solutions, and, as Perrin showed, to dilute emulsions.

Taking a broad view of the subject, Perrin saw that instead of accounting for the Brownian movement as a consequence of an assumed molecular structure of the suspending liquid, one might logically deduce the existence of molecules from the observed phenomenon of the Brownian motion. Perrin[10] pointed out that what is really strange and new in the Brownian movement is that it never stops, which at first seems in contradiction to our everyday experience of friction. If, for example, we pour a bucket of water into a tub, in a short

[9] Einstein, *Ann. der Physik*, 1905, p. 549 and 1906, p. 371; Smoluchowski, *Bull. de L'Acad. des Sciences de Cracovie*, July, 1906; *Ann. der Physik*, 21: p. 756, 1906; Perrin, *Annales de Chimie et de Physique*, September, 1909. Translated by Soddy, London, 1910, Taylor and Francis. (An excellent summary of the whole subject.)

[10] *Ibid.*

time the motion possessed by the liquid mass apparently disappears. As a matter of fact, what disappears is the coordination of the movement of the different parts of the water. The velocities at different points, at first almost equal and parallel as the water left the bucket, become more and more random and chaotic, distributing themselves in a fashion the more irregular the smaller the parts which we consider.

Perrin pointed out that this de-coordination does not proceed indefinitely. On the scale of microscopic observation, at the level of the Brownian motion, a re-coordination begins to be evident. If, at any instant, certain of the suspended particles stop moving, there are, at the same instant, in other regions particles which change from rest to motion. Since, therefore, the distribution of motion in a fluid does not progress indefinitely, but is limited by a spontaneous re-coordination, it follows that the fluids are themselves composed of granules or molecules which can assume all possible motions relative to one another, but which constitute a barrier to the further subdivision of the motion. If such molecules had no existence it is not apparent how there could be any limit to the decoordination of motion.

Whether atoms might again be subdivided was generally regarded during most of the nineteenth century as rather an academic question. Physical changes, such as water to steam, could be explained without going below the molecule; chemical changes without going farther than the atom. But toward the end of the nineteenth century there were discovered new phenomena which not only furnished a fourth line of evidence for the reality of atoms, but opened our eyes to the existence of subatomic particles. This line of evidence arose from the study of the electric discharge through gases and from the discovery of radioactive substances.

In the early 1870's the chemist William Crookes was making weighings with a vacuum balance, and found some unaccountable disturbances, arising apparently from one pan of the balance being a little warmer than the other, as might occur by one side of the balance being warmed by sunlight. It was natural to account for these irregularities by convection currents, and the remedy was obvious: one must have a better vacuum. About this time the mercury air pump had undergone some improvements, and Crookes, becoming interested, added some refinements of his own which enabled him to attain a vacuum of better than a millionth of an atmosphere. Strangely enough, he found at this high exhaustion that the disturbing effect of light increased, and he was led to the construction of his radiometer. In such a vacuum the mean free path of a molecule of residual air becomes a matter of centimeters, comparable with the dimensions of the vacuum tube, and in such tubes Crookes discovered some novel and beautiful electrical effects which he exhibited at the meeting of the British Association at Sheffield in 1879.

Crookes showed that there was in such a tube a steady stream of electrified particles shot out from the cathode. He unquestioningly supposed these to be molecules of the residual air. He showed that this stream of particles could be deflected by a magnet, but did not follow up this point mathematically. This was perhaps natural, for at that time Maxwell's electromagnetic theory was still struggling for recognition. Moreover, Crookes was a chemist and not a mathematical physicist. It remained therefore for later workers (J. J. Thomson, Townsend, Wilson) to show that the negatively charged particles in a Crookes tube were not molecules or even atoms, but bodies of a minuteness hitherto unknown, being about 1/1,800 of the mass of a hydrogen atom. For these tiny bodies a new name was needed, and they were called "electrons" (electro-ions), the term "ion" having been for some time in use in electrolytic phenomena.

In the experiments of Thomson and others which made us acquainted with the properties of the electron the experimenters had to deal with these particles in large numbers, and the question naturally arose whether the results might not represent merely an average of a perhaps widely varying quantity. This question was answered by Millikan in 1909, when by a very ingenious method he succeeded in isolating individual electrons and measuring their charges. These he found to be always the same from whatever material the electrons were derived.

The possibility of the existence of particles still lighter than the electron has not been overlooked. Several observers, the most prominent of whom was Ehrenhaft, claimed to have found experimental evidence of such particles. Millikan, however, after an exhaustive discussion of the subject, is of the opinion that the evidence for a sub-electron is unsatisfactory.

Just why, in the Crookes tube, a similar stream of positively charged particles was not emitted from the anode was a question not raised by Crookes. Some years later, in 1886, such particles were found by Goldstein, who called them "canal rays," from the shape of his apparatus. It was again some years before their nature was ascertained. Upon the discovery of radioactive bodies by Becquerel in 1896 it was found that these bodies emitted positively charged particles in abundance as well as negatively charged electrons. Eventually it was found that these positively charged particles were of two kinds, both much heavier than the electron. One kind of positive particles, called an alpha-particle, was found to have the mass of a helium atom (atomic mass 4), and the other kind called a proton, to correspond to a hydrogen atom (atomic mass 1). Both the alpha-particle and the proton, however, carry an electric charge equal and opposite to that of the electron. It was but natural to suppose that the alpha-particle was not an elementary unit, but was made up of four protons. Protons and electrons, therefore, came to be regarded as the ultimate building blocks of nature.

Much in the same way that the Brownian motion enables us to see the effect of the impacts of the invisible molecules there is a way in which we can see the impacts of the heavy and energetic alpha-particles emitted by radium. Take a watch or clock with luminous radium paint on its dial into a dark closet and examine it with a good magnifying glass; a jeweler's eyeglass will serve well. The glow, which, to the unaided eye, appears uniform and steady, can be seen under the glass to be made up of myriads of tiny sparks, flashing up and dying down continually.

Take a piece of lump sugar into the dark closet and break it by pressing on it with a knife blade. A flash of bluish light can be seen for an instant along the edge of the knife as the sugar breaks. Light developed by the fracture of crystals is a well-known phenomenon, called "tribo-luminescence." It is quite different in nature from the spark produced when flint and steel are struck together. It is probably tribo-luminescence on a small scale which produces the glow of radium paint. This paint is composed usually of a special form of zinc sulfide mixed with a trace of a radium compound. The alpha-particles emitted by the radium strike the submicroscopic crystals of zinc sulfide and each tiny fracture generates a flash of light.

The great disproportion (about 1,800 to 1) in the relative masses of the negative electron and the positive proton has not failed to attract attention. Dirac speculated on the possible existence of what he called an anti-electron, of a mass equal to that of the electron, but carrying a positive charge. Some of his conclusions were so strange that it was difficult for many physicists to take his ideas seriously. For one thing, it ap-

peared, according to Dirac, that this anti-electron would of necessity be a very short-lived affair. Collision with a negative electron, or indeed with an atom or a molecule would, as Dirac thought, terminate the independent existence of the anti-electron, and in its stead would appear a little group of light waves, called a photon.

But in 1932 positively charged particles of very much this nature were discovered, of mass substantially the same as that of the electron. Recent experiment has shown that these particles, which have been called positrons, are in all probability as short lived as Dirac's anti-electron, and that after their brief existence is terminated by a fatal collision, they are reincarnated as light.

A negative electron, on the other hand, seems to be eternal. It may collide with atoms or molecules and rebound, suffering no change except in direction and speed. The reason for this fundamental difference in stability between the ultimate and positive particles is as yet not clear.

As long ago as 1920 Rutherford had directed attention to the theoretical possibility (perhaps even the probability) of the existence of an electrically neutral particle corresponding to the proton. In the same year in which the positron was discovered such a neutral particle was found by Chadwick. Whether this particle (called a neutron) is a close combination of a positive proton with a negative electron or whether it is an independent entity is not known.

We may summarize our present knowledge of nature's ultimate particles as given in the accompanying table.

It is not impossible that the vacant spaces in this table will at some time be filled, as has already been the case with the periodic table of the elements.

The philosopher is interested to observe that this fourth line of evidence for the existence of atoms, perhaps the most convincing of all, actually suggests in one of its aspects a compromise on equal terms between the discontinuous and continuous theories of matter. This aspect is that which is known as wave mechanics.

	Heavy particles (mass equal to hydrogen atom)	Light particles mass 1/1,800 of a hydrogen atom)
Positive charge	*Proton*	*Positron*
Negative charge	*(Unknown)*	*Electron*
Neutral	*Neutron*	*(Unknown)*

The electron in some of its activities acts like a particle; in some other respects it behaves as though it were a little group of waves, and the evidence in one case is just as good as in the other. Wave mechanics suggests a compromise to meet this difficulty.

The atom, according to Schrödinger, may be regarded as a group of waves (never mind of what) constituting a localization of energy at a certain point in space. Schrödinger's equations show that the amplitude of this group of waves falls off rapidly with the distance from the center of the group, so that the boundary of the atom, while strictly speaking vague, is for all practical purposes fairly definite. But, again strictly speaking, this amplitude falls off asymptotically to infinity, and in consequence two Schrödinger atoms, however far apart, are connected by an infinitesimally tenuous bond of the same nature as their own substance.

This modern adaptation of an ancient idea, this bridging of the centuries, calls to mind the well-known quatrain of Omar:

Myself when young did eagerly frequent
Doctor and Saint, and heard great argument
About it and about; but evermore
Came out by the same door where in I went.

THE LANGUAGE OF TREE RINGS

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THE idea of studying tree rings was conceived by Dr. A. E. Douglass, of the University of Arizona, in 1901 while on a buckboard trip through the great pine forest of northern Arizona. His interest in solar changes, especially the sun-spot cycle, led him to wonder if by chance that cycle might in some way influence the amount trees grow during a year. If such should be the case, the record of sun-spots by one stroke would be pushed several centuries back of any records kept by man. It might be, of course, that the sun does not act directly on the trees but acts through an agent, such as some phase of climate. If so, climatic records would also be greatly extended. Thus he reasoned, and the trees themselves in the years that followed have testified to the correctness of the reasoning.

HOW TO READ TREE RINGS

If one carefully examines sections of trees which lived together as neighbors he will notice that the rings are not all of the same size but that in many cases they vary a great deal in width from narrow to average and up to big. A passing acquaintanceship will reveal this variation in width. Permanent friendship, however, will establish such familiarity with the individual rings of a single specimen that the identical rings can be recognized in an adjacent tree. Therein lies not only the thrill of discovery but also one of the secrets of reading tree rings.

Evergreen trees, such as pine, fir, and piñon, are more easily studied perhaps than others. With the coming of spring the tree awakens rather suddenly from its winter sleep. Growth is rapid at first and the wood formed is light-colored and porous. As summer advances, growth gradually slackens. The light-colored wood merges into a band which is darker and denser. When winter shuts down, the tree "closes shop," so to speak, and all growth ceases so abruptly that a sharp line marks the outside boundary of the wood put down during the spring and summer. Therefore, an annual ring consists of the light-colored wood, or spring growth, plus the dark-colored wood, or summer growth, and it is marked off by a sharp line at its beginning and one at its end. We are often led to say, for the sake of brevity, that an annual ring extends from the sharp outside of last year's ring to the sharp outside of this year's ring. Since we know such to be a fact, the art of ring reading lies in the acquisition of great familiarity with the variable sizes of rings and the invention of some scheme whereby the characteristics we come to recognize may be set permanently and usefully on paper.

Let us then return our thoughts to the subject of ring variations. If we obtain a collection of a dozen or so specimens from a certain locality and at leisure familiarize ourselves with the rings we will very soon notice that each ring possesses a surprising amount of individuality, so much so in fact that a very narrow ring on one specimen can be recognized in counterpart on most of the others. It does not take long until here and there on different specimens we can pick out rings very closely alike. The feeling comes to us that we are following something which repeats itself in

the different trees, something which is telling the same story over and over. Now, if we count out from a narrow ring we will find, say, the sixth ring very narrow, and the tenth and twelfth. These telltale rings, spaced at constant intervals on all specimens, establish with certainty the close relationship among the trees and the similarity of their records.

Ring sequences quite commonly possess outstanding configurations which serve as "finger prints" of identification in every sense of the words. One series of rings we have at hand reads in part as follows: ring No. 3 small; 4 and 5 about average; 6 rather small; 7 small; 8 to 11 average; 12 small; 13 average; 14 to 16 big; 17 average; 18 rather small; 19 to 21 about average; 22 rather small; 23 and 24 about average; and 25 and 26 very small. Another series gave the identical intervals as listed save that each number was greater by 20, thus: 23 small; 24 and 25 about average; 26 rather small; 27 small, and so on. Such configurations are just as striking, just as characteristic and just as symbolic of tree identity as is the pen and ink signature of personal identity. A wood section showing a signature reveals its intimate secrets as surely as a museum specimen with a glaring label.

The comparison, *i.e.*, cross-dating, of our group of trees can be verified by paying attention to the dates on which the rings were grown. Suppose the trees were felled in the late autumn of 1920. All outside rings were formed during 1920 and represent that year. We count inward and place a single pin prick on 1910, three on 1900 for the century mark, one on 1890 and so on, and two on 1850. Narrow and big rings and the intervals between them can now be directly compared by the dates. We notice in particular the rings for 1913, 1904, 1902, 1900, 1880 and 1864, for example; they are small in all the trees. It should be pointed out hastily that we judge a ring to be small in relation to its near neighbors only, especially the two or three immediately preceding, and not upon what we might decide beforehand should be a typical size. Since ring widths are judged relative to each other, even a group of small rings will generally possess a few rings narrower than the rest. It is this possession of very small and very large rings spaced at constant intervals and existing consistently over a homogeneous area of country which makes it possible not only to cross-date from tree to tree with certainty but also to plot a curve of the ring widths in order to show the varying success of the tree in its environment.

So far the reading of tree rings appears to be quite a prosaic task but when apparently we are forced to crowd eleven rings into, or stretch nine rings out over, a ten-year interval, then tree rings become fascinating and challenge us to read the story they have to tell. Eleven annual rings in ten years is so obviously impossible that somewhere there must be a false ring which at first sight has the appearance of an annual. It is well at this point to recall two facts: (1) the annual ring extends from the sharp outside of last year's ring to the sharp outside of this year's ring, and (2) the annual ring itself consists of light-colored spring growth plus dark-colored summer growth, the light merging forward gradually into the dark, and not the reverse. Now, if we examine the ten-year interval closely we shall probably find somewhere a band of dark wood which fades into the light wood on both sides, indicating that the tree began to form typical late growth material rather too early in the season and had to return to early growth for a time before the actual growing season ended. We call such a ring a double

because of the two dark bands, one of which fades on both sides and the other of which fades on the inside and ends in a sharp line on the outside (Fig. 1). The double, or "false ring," usually lies just inside the band of true late growth.

Occasionally a thin line of summer wood lies in the middle of what otherwise would be a single annual ring. Is it a so-called "mid-line" or is it the outside of a separate annual? The entire circumference of the tree may have to be examined in order to reach a decision. If the line moves over so as to unite with an adjoining dark band, then it is not a mid-line, but part of a separate annual ring. If the line does not move over, but ends "in the air," it is a true mid-line. Another method remains, should the above one fail to yield a decision. All the specimens of the collection covering the same time interval must be examined. If some of the specimens lack the line under question at the appropriate place, then it is very probably a mid-line.

The presence of nine rings to cover a ten-year interval does not seem so obviously impossible since one may have been lost. Of course, it was never lost—the tree simply did not grow a ring for a certain year on that part of the trunk because of adverse living conditions. The name "missing" has been applied to such rings, and it is a good one. It may be imagined what difficulties arose because of missing rings during the inception of tree-ring study. Before he had discovered that rings could be missing, Dr. Douglass made the following note (February 15, 1904): "I find small rings not to be depended upon. . . ." Either the intervals between two small rings did not remain constant on different specimens, or sometimes a ring was small and another time it was not. In both cases missing rings were to blame. The small ring on one specimen was absent on the other—simple when discovered but no end of trouble previously.

Diagrams (Fig. 2) perhaps will help us quickly to an understanding of missing rings. Diagram a shows ring No. 3 of average size. In b it is very small, and sometimes so much so that it is microscopic. In c and d ring No. 3 is locally absent (lo. ab., for short) over a part of the circumference, and in e it is entirely absent, or missing. We can see at once that the existence of ring No. 3 in c and d can be established by close inspection of the entire circumference. Constant carefulness will prevent our overlooking rings locally absent. The case of diagram e is different. Here cross-dating with other specimens covering the same time interval not only reveals the lack of one ring for the interval but indicates exactly where the missing ring should be supplied as well. The thorough check provided by cross-dating in the revelation of doubles, mid-lines

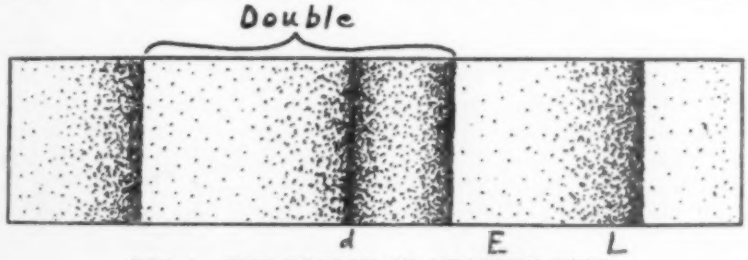


FIG. 1. THE DOUBLE OR "FALSE" RING.

THE BAND OF DARK-COLORED WOOD LABELLED "D" WAS FORMED DURING THE GROWING SEASON AND NOT AT ITS END. E = EARLY GROWTH OR SPRING WOOD FOR THAT PARTICULAR RING AND L = LATE GROWTH OR SUMMER WOOD.

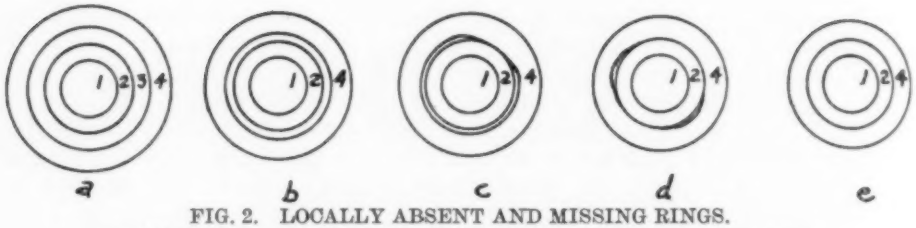


FIG. 2. LOCALLY ABSENT AND MISSING RINGS.

RING NO. 3 IS OF AVERAGE SIZE AT THE LEFT AND IS MISSING AT THE RIGHT.

and locally absent and missing rings makes the process one of fundamental importance to the field of tree-ring research.

It may be of interest to quote a passage from the notes of Dr. Douglass giving the first hints of cross-dating in the dawning realization that rings on opposite sides of a tree were identical. "Tried opposite sides and find that rings on opposite sides readily identify. Identified the 1801 ring and others about 1750 and 1850 without knowing their precise place and then counted and found them correctly placed with reference to each other." The note was written on February 15, 1904. But not until 1911 was the full importance of cross-dating realized. It was the most significant step in all tree-ring studies; it gave the needed accuracy to ring identification and a solid foundation from which to read the story of tree rings.

A knowledge of how to "read" tree rings and how to cross-date specimens will permit us to understand the construction of a tree-ring calendar, or a so-called master chart for a given region if we can devise some graphic method to represent the individual rings. To make such a calendar possible the region must possess living trees as well as material from forests which lived before the present one. A wide choice of specimens properly selected so that they dovetail together is a necessary requirement for a well-balanced, thoroughly verified calendar. Fig. 3 shows how the chain of specimens wrought out of strong links safely articulated reaches unbroken

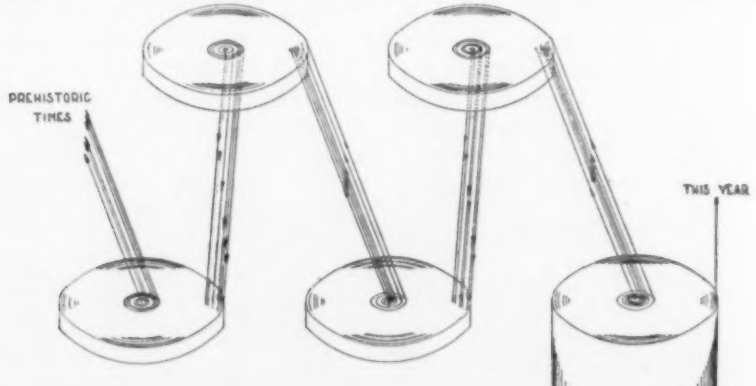


FIG. 3. THE CONSTRUCTION OF THE TREE-RING CALENDAR.

THE YOUNGEST SPECIMEN AT THE INSIDE MATCHES THE OUTSIDE OF THE NEXT OLDER, THE INSIDE OF THIS ONE MATCHES THE OUTSIDE OF THE SECOND OLDER, AND SO ON INTO PREHISTORIC TIMES. EACH SPECIMEN BRIDGES THE GAP FROM THE PREVIOUS RECORD TO THE ONE FOLLOWING.

from the youngest ring at the right to the oldest at the left. The diagram is schematic and ideal. Nevertheless, it illustrates two things: first, that the inside of the youngest tree matches the outside of the next older and, second, that each specimen not only matches the previous one but also extends it backward in time. Thus a tree-ring calendar is built up with every ring definitely dated at a particular year if each part of the entire sequence has been verified and duplicated as much as abundance of material permits or until uncertainty no longer exists. The process whereby a ring record is extended either forward or backward in time is known as chronology building. It is accomplished by means of identifying like rings and like intervals on different specimens, as was previously explained, or in other words, by means of cross-dating.

A tree-ring calendar gives us a standard sequence of rings and represents our greatest desire for any region. In fact, the working out of a standard sequence is the initial and all-important task in tree-ring study. That done, other problems dependent upon the standard can be approached with definite hope of solution. Let us suppose, for instance, that we come into possession of a mass of material wholly unfamiliar to us. The first specimen selected shows certain noteworthy rings and certain intervals which can be recognized on a second, a third and many others. Since it is not practical to remember all the separate sequences we are justified in placing the specimens side by side, selecting those characteristic rings common to the entire lot, and holding them in mind as a standard sequence representative of the collection. True calendar dates not being known as yet, an arbitrary zero may be assigned to some one ring and the others numbered accordingly. Such a sequence is then known as a relatively dated standard, or briefly, an R.D.S.

Now an R.D.S. may occupy one of three positions in relation to the real standard sequence; that is, it may precede, follow or match part of the standard. If it matches, actual dates may at once be assigned and the problem is solved. If the R.D.S. does not match, patience must be exercised until the record has been extended far enough by means of the process of chronology building so that in the extended form it joins firmly and surely onto the dated standard. Gaps between an undated sequence and the tree-ring calendar have been bridged from time to time in the past. The most famous of the gaps, just prior to 1300 A. D., was closed by material collected by the National Geographic Society Expedition of 1929.

A little consideration will reveal the potent nature of the scheme involved in setting up an R.D.S., for it helps directly in the solution of all major problems concerned with chronology building and helps in the dating of masses of new material. In actual practise in our tree-ring laboratory the R.D.S. system is of invaluable assistance and is used constantly. Several such relatively dated standards are in existence at the present time. Should a new region fail to yield a dated standard at first, recourse must be had in an R.D.S. Relative dating has had great value in the study of collections from the ancient ruins of Indian pueblos in the Southwest and could be used in similar fashion with ancient material from other parts of the earth.

Down to here we have assumed that all ring features are held in the memory. Truth to say, the memory method of ring reading has enormous value because of its great facility and ease of application under all conditions and because the wood upon which memory is based possesses all the features characteristic of a given sequence, something no secondary method of ring representation could

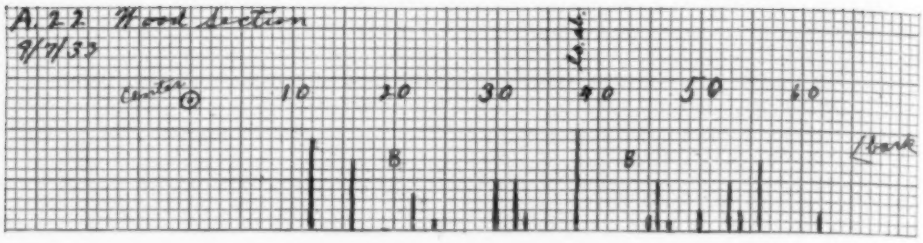


FIG. 4. THE SKELETON PLOT.

THE YEARS, AND THEREFORE THE ANNUAL RINGS, ARE NUMBERED FROM LEFT TO RIGHT ON THE PRINTED LINES. EACH LINE REPRESENTING A NARROW RING IS INKED TO A LENGTH WHICH IS INDICATIVE OF THE NARROWNESS IN THE SENSE THAT THE NARROWER RINGS ARE MARKED BY LONGER LINES. "B" STANDS FOR "BIG," AND "LO. AB." FOR LOCALLY ABSENT.

show. The memory method, however, becomes impractical if not impossible, as sequences accumulate in number. Hence it becomes necessary to devise a means of placing the diagnostic features which reveal the essential characteristics of a specimen upon paper for permanent use.

Let us take an undated specimen as an example. We count out from the center, placing a pin prick in the tenth ring, the twentieth, thirtieth, and so on. In that way each ring has a specific number. A sheet of paper is prepared by placing the number of the specimen, the date and the type of wood at the top. Then we "read" the rings. The numbers of all rings having diagnostic features are placed in a column so that telltale rings and the intervals between them are recorded. Suppose ring No. 12 is extremely small: we underline the written figure 12 three or four times. Suppose ring No. 16 is very small: we give it two or three lines. Ring No. 22 is rather small: we give it one line. Ring No. 24 is just noticeably small: it received no line. If ring No. 20 is unusually big we note the fact on the paper so: (20 B). It must not be forgotten that, throughout the whole process of reading, rings are judged small or big in comparison with their immediate neighbors only. The sheet of paper when completed contains the so-called number plot and gives a record which is permanent for our files but which is very cumbersome to use as a record by itself.

In order to make the number plot useful in a practical and rapid way it is changed into a skeleton plot. Coordinate paper, with centimeters marked by heavy lines and with the small divisions two millimeters square, is cut lengthwise into strips four and a half centimeters wide. If one strip is not long enough two or more may be glued together, care being taken that the divisions match accurately. Each vertical two-millimeter line represents an annual ring and the lines are numbered from left to right. Ring No. 12 was taken to be extremely small; a long ink line is therefore drawn at the appropriate place on the coordinate paper. Ring No. 16 receives a somewhat shorter line than No. 12, No. 22 still shorter and No. 24 just a touch (Fig. 4). The completed skeleton plot gives us something very convenient to use, since it is easily carried about and since it can be readily placed on top of another one to see if the inked lines match, that is, cross-date.

A further word may well be given on the individual skeleton plot. If too many lines are drawn the plot becomes

meaningless. Only those rings which are conspicuous, telltale and diagnostic should be represented for the same reason that in our daily lives we are more apt to remember and compare people and places because of certain outstanding characteristics rather than because of trifling details.

Let us carry our knowledge of skeleton plots back to the collection of specimens considered previously and construct plots for all individuals. It is commonly more convenient to cross-date skeleton plots than it is to compare pieces of wood. Then, too, plots may be carried about and matched at odd moments. If plots which cross-date are placed side by side in correct position year for year the lines common to the group may be copied down on a separate strip of coordinate paper (Fig. 5). Such a procedure merges the features common to all the individuals into a single plot, the so-called standard or master chart. Chronologies either relative or absolute are built up in this way and in actual practise the tree-ring calendar in the form of a master chart is used for dating and correlation purposes. The master chart for the Central Pueblo Area of Arizona and New Mexico built up by Dr. Douglass by the method of chronology building illustrated in Fig. 3 now reaches back more than a thousand years. It was made from living trees and from beams incorporated in the pueblos by the Indians of early historic and prehistoric times. For each of a thousand years we have a separate ring, a telltale witness to all the vicissitudes of environment, however good or bad, for tree-growth. The rings picture the life histories of the trees, the struggle against famine and the luxuriance of plenty. Each factor influencing the well-being of the tree, whether it be the soil of the earth or the rays of the sun, the snows of winter or the drought of

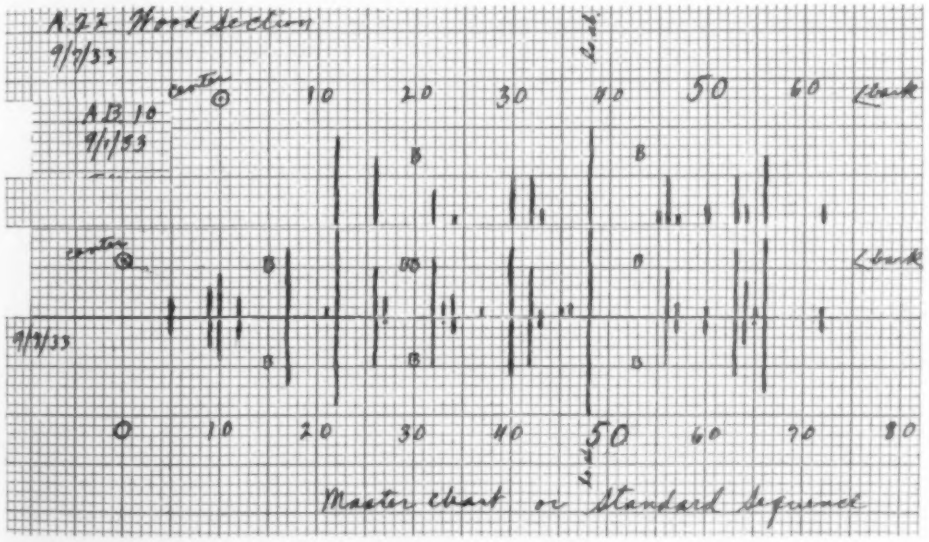


FIG. 5. THE CROSS-DATING OF SKELETON PLOTS AND THE CONSTRUCTION OF A MASTER CHART.

THE NUMBERS ON THE MASTER CHART ARE FOR ILLUSTRATIVE PURPOSES ONLY. THE PLOT LABELED MASTER CHART IS ACTUALLY A RELATIVELY DATED STANDARD IN THIS CASE.

summer, leaves its impress somewhere in the body of the tree. If we have the eyes to read we may glean bits of the fascinating story not only for the year just gone but also for a thousand years ago, and even a million years or more back in the history of plant life.

What Tree Rings Tell

Reading of tree rings and the building of chronologies are intriguing puzzles, ever leading the reader onward from one solution to another without end. The work may be difficult, painstaking and laborious as a rule; yet it comes to be viewed in the light of a genuine pleasure, time-consuming and compelling. Nevertheless, ring reading is but half the story. The application of the knowledge gained and the story written in the rings are after all the things we want to do and know. We must learn to read and understand.

The master chart, it will be remembered, shows the nature of the rings for all the years throughout its course. Suppose some one sends us from the region of the master chart a specimen which he wants dated. We examine it, and perhaps the narrow rings and intervals between them will reveal the dates. If memory fails, we construct a skeleton plot that is moved slowly along the master chart until a fit is obtained. Thus, the specimen is dated and the outside ring gives the exact date when the tree was killed or cut down. The possibilities of dating become strikingly apparent on our learning that among the Indian ruins of the Southwest we can tell to the year in most cases when the timbers were cut for the original structure, for repairs or for reconstruction by later generations.

The Indian pueblos of the Southwest are simply one example. Consider the possibilities of the system in connection with the dating of prehistoric materials from other parts of the earth. What a revelation we may aspire to in the future! Many problems, legal, historic or scientific, may be capable of solution.

Now we must turn to the story that tree rings themselves have to tell. Fire, lightning, pest effects, wind, disease, frost—all these and others, highly interesting in themselves, leave their marks upon the growing tree, but the chief objective in tree-ring work lies along somewhat different lines. When we make a collection we desire normal, healthy trees, trees representative of the normal conditions of the environment under which they lived. A tree is more than an organism modified by its environment, it is a manifestation of that environment—a complex of cells born of and nourished in the natural products of a locality and shaped through life by the interaction of materials and forces amalgamated in the body of the tree. Each factor having an influence on the tree leaves its impress. It is a task for our eyes to learn to read the telltale signs and unravel the skein of evidence.

The personal life of a tree, whether in success or failure, in ease or adversity, is an illuminating subject for study, whether we know the exact name of the tree or not. The individual tree can not, of course, move about; it must take things as they come. When conditions are good and all factors work in harmony our trees are happy, prosperous and well fed; but when conditions are bad and certain factors become weak or antagonistic the trees are miserable, pauperized and undernourished. Tree-growth, in other words, more or less faithfully records living conditions in particular for a single locality or in general for an entire region. Since the general story should properly come first, we merge the records of a group of trees so that we may obtain an insight into

the conditions or factors affecting the forest as a whole. The following remarks are made from this larger regional view-point and, it is hoped, they will illustrate how bits of the story of the past are revealed by tree rings. For the past lives again in him who learns to read.

The mutual interaction of factors in near optimum amounts is necessary to the constant well-being of a tree. Any essential variation will leave a mark. In certain regions the fluctuations of some one factor are so important that it serves as the major control of tree-growth. Perhaps it is water supply, sunshine, temperature, behavior of the sun or others.

Let us consider the case in which water supply represented by rainfall is just enough on the average for the requirements of the trees. The average ring, then, will reflect the average rainfall. By the same token, the narrower the ring is the less the rainfall of the corresponding season, in general. A very narrow ring tells us that a tree is fighting for its existence. Times are hard, water and food are scarce, life is precarious, and a few weaker trees may die. A ring locally absent perhaps signifies that only a few of the roots were able to secure water and food: they were not sufficiently plentiful for the tree to form a complete ring. On the other hand, a large ring indicates more than average rainfall. We may well imagine the happiness and peace of mind of the tree, were it conscious, when it feels assured of plenty to eat and drink.

The double ring is of equal interest. Conditions become unfavorable in the late spring and the tree begins to "close shop," as it were, by forming some dark-colored summer wood. As the harsh conditions relax and the summer rains begin, the growth gradually returns to the spring type for a time prior to the real end of the growing season. Thus, doubles appear to tell us of a double season, that is, a year in which the late spring and early summer drought is so severe and so protracted that the precipitation of the previous winter can not last over the dry spell.

Once interested in life in relation to its surroundings we may begin to vision the breadth of the investigation. It is not a single highway but an intricate pattern of diverging roads, each one beckoning for exploration and promising the fruits thereof.

If we measure the rings of a sequence accurately in millimeters and construct a graph of the measures plotted year by year we obtain a wavy line, or "curve," composed of successive crests and troughs. The ring measures in such form are ready for an analysis, which consists of a study of the intervals between successive crests. Since the crests represent times when the trees grew rapidly and flourished, they speak to us of causes and associations which work intermittently to the benefit of the trees. Evidence has accumulated, for instance, showing that variations in tree-growth correspond to a certain extent to variations in the sun. The sun probably exerts much of its influence through the agency of rainfall on the earth. We see at once that astronomy and meteorology lend material assistance in the study of tree rings. But observations of the sun go back only to the early decades of the seventeenth century. Therefore the rings of the giant Sequoias extending backward several thousands of years have in their turn something of value to tell astronomers. Meteorology likewise receives a long record of weather conditions. Since a forest as a whole is subject to climatic variations, the science of climatology gives as well as receives information of importance.

Archeology happily furnishes us with a wealth of prehistoric material, which on being dated supplies archeologists with exact dates of pueblo occupation. Fossil trees are not at all uncommon down in the rocks of geologic time. With our knowledge of what tree rings tell we can not only trace a lightning scar that blasted its way down a tree trunk millions of years ago, but we can also read something of the weather and climate in the dim ages gone. Are those same rings trying to tell us something of the history of the sun? Botany is not the least of the fields of man's endeavor to have a vital influence on the study of tree rings. The two studies constantly must work hand in hand. Last of all, there is the science of ecology which is intensely interested in that most fascinating of all stories on the face of the earth, the relation of living things to their surroundings. Through the whole gamut of the sciences each has a necessary part, to give and to receive, in the ecological study of trees and the rings they create from year to year.

So we have a sort of mutual benefit association. A list of the members is rather impressive: astronomy, meteorology, climatology, archeology, geology, botany and ecology. It may not be long until chemistry and physics are invited to do their rightful share. When we consider leisurely that tree-growth not only reaches backward in time but also stretches through space to all parts of the earth we begin to see a vista of vast possibilities for the inquisitive human mind. Whole regions of knowledge await investigation. Fortunately a well-marked trail has been blazed into the unknown by the founder of tree-ring studies in whose mind the idea was originally conceived and painstakingly elaborated.

JENNY HANIVERS, DRAGONS AND BASILISKS IN THE OLD NATURAL HISTORY BOOKS AND IN MODERN TIMES

By Dr. E. W. GUDGER

BIBLIOGRAPHER AND ASSOCIATE IN ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY

A Modern Jenny Haniver

Some years ago Mr. S. Altman of Brooklyn came to my office bringing the curious object shown in Fig. 1. I explained to him that this was a Jenny Haniver, made of a ray transformed by hand and dried into this mythological monster. He very kindly left it with me until I could have made the photograph reproduced as Fig. 1. This was filed away and, as it came to me, like material was added with a view to the article now presented.

The scanty history of this specimen is as follows. Years ago Mr. Altman's father purchased an old colonial house on Ocean Avenue, Brooklyn. The house had been long unoccupied when it was turned over to the wreckers in 1925. Among the old things rescued from it by Mr. Altman was this specimen, which he found hanging over a mantel in one of the rooms. Its source can not be traced further.

The head-dress of this Jenny Haniver is made of the rostral cartilage, with the flexible membranes partly wrapped about it. The eyes are artificial ones inserted in the nostrils. The flat mouth has been pulled out to give the jaws somewhat the curvature of those in a primate. The tissues on either side of the mouth have been distended into bulging cheeks. The upper parts of the pectoral fins have been folded back behind the head, leaving the remainder of the fins to form the wings. The appendages of the pelvic fins of this male fish have been manipulated to form something like legs, and these are supported by wires run through the tissues. Part of the fin membrane is seen on the outside of each "leg." At the junction of fins and body are the conjoined enlarged bases of the fins with points extending upward and outward right and left somewhat resembling the pelvic arch of a primate—of which they are in a certain sense the antecedents.

Such, then, is a modern Jenny Haniver, made of a skate distorted by hand and dried in the form of this mythological monster. It is to be regretted that the history of this specimen can not be traced further than the brief account already given.

The Origin of the Name Jenny Haniver

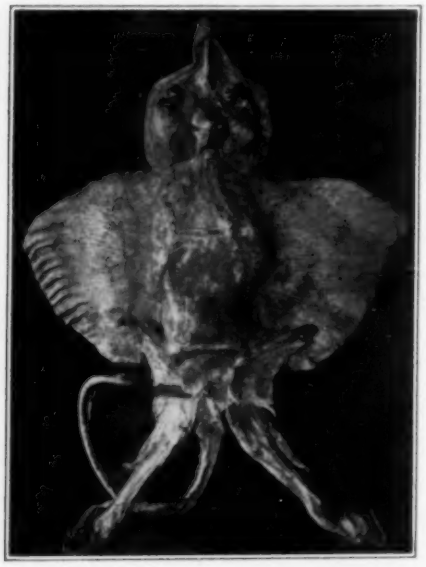
The appellation, Jenny Haniver, is as interesting as unusual. I have known of it for years but have no clear idea of its origin. The only other writer on these manipulated rays who uses this name is Mr. Gilbert P. Whitley of the Australian Museum, Sydney, whose article will be referred to later. We have both vainly sought to trace the origin of the term and have failed. The word is not even in the Oxford New English Dictionary, nor in any of the dialect dictionaries we have been able to examine. But Mr. Whitley got the following suggestion from Dr. Rivis Mead of Waitara, New South Wales, who had formerly owned a Jenny Haniver. Dr. Mead writes:

> The distorted small skate sent you was purchased in a shop in Whitby, Yorks, England,

where the saleswoman had a long story about their capture on the coasts of Belgium and Holland. The name as given to me sounded like Jeanie Hanvers, so maybe it has something to do with "Anvers," the French name for Antwerp—a probable place of their origin. Possibly they are made there by fishermen or sailors.

The History of These Mythological Monsters Traced in Figures from Old Books

For the origin of these man-made monsters, we must go back to the mid-



—Courtesy of Mr. S. Altman

FIG. 1. A MODERN JENNY HANIVER
THIS IS MADE OF A SKATE, SHAPED BY HAND AND DRIED INTO THE FORM OF A MYTHOLOGICAL MONSTER.

dle of the sixteenth century, to the earliest books on fishes ever written. It was about this time that the Dutch vessels trading with China and the western islands of the Malay Archipelago brought back hand-made mermaids (half monkey and half fish). These and their manufacture had already been made known to Europeans by the great medieval traveler, Marco Polo (in Book III, chap. ix—vol. II, pp. 285–286 of the Yule-Cordier ed. of 1921). I strongly suspect that these "mermaids" were largely responsible for two remarkable "fishes," the "monkfish" and the "bishopfish," figured in the books of those early founders of ichthyology, Belon, Rondelet, Gesner and Aldrovandi. Perhaps reproductions of these figures and brief references to them may be of interest.

The earliest published figure of the monkfish is found in what is the first treatise on fishes in the history of the world, Pierre Belon's

De aquatilibus, Libri duo
Cum eiconibus ad vivam ipsorum effigiem
quod eius fieri potuit, expressis
Parisiis, MDLIII.

On page 39 is found the picture shown herein as Fig. 2. Of the origin of this "fish," Belon says that it was taken in Norway at Diezunt near the town of Den Elepoch and that it lived three days, giving out (not unwarrantedly) lamentations of distress.

Belon, in the French version of his book published at Paris in 1555, gives the same figure, which he says is that of "un homme marin." He then discusses sirens, tritons, naiads and mermaids; and gives several accounts of these later. Evidently he links his monkfish with the mermaid.

Guillaume Rondelet, a contemporary of Belon, in his book, "Libri de Piscibus Marinis," Lugduni [Lyons], 1554, has a better drawn figure of the monkfish, but one differing only in details from Belon's. However, his account of the fish is much fuller. After speaking of marine monsters, he adds that:

Among these let us place that which was in our time captured in Norway in a tempestuous sea. All who saw it at once gave it the name of monk, for it had the visage of a man, but one rustic and uncouth. Its head was shaven and smooth and a cloak like that of a monk covered its shoulders. Instead of arms, it had

two long fins, its lower part ended in a broad tail, and its middle part was broader and formed like a military cloak. The picture of this was given me by the illustrious Margaret, Queen of Navarre. . . . She had received this effigy from a nobleman, who had brought a similar one to the Emperor Charles the Fifth then passing through Spain. This nobleman told the queen that he had seen this monster captured in Norway at Diezum near the town called Denelopoch after it had been thrown on shore by the huge waves of a great storm. Furthermore Gisbertus the physician showed me in Rome a picture of this same monster differing in no whit from mine.

However, Rondelet, who was regius professor of medicine in the celebrated

—*After Belon, 1553*

FIG. 2. THE FISH IN THE DRESS OF A MONK

THE MONKFISH OR SEA MONK.

medical school at Montpellier in southern France, did not swallow this monkfish whole, but like the scientific ichthyologist he was, added that "To set forth my own views, I think that certain details beyond the truth of the matter have

—*After Rondelet, 1554*

FIG. 3. THE FISH GARBED LIKE A BISHOP

THE SEA BISHOP OR BISHOPFISH.

—*After Günther, 1880*

FIG. 4. LOWER ASPECT OF HEAD OF RAIA LEMPRIERI

NOTE THE RESEMBLANCE TO A HUMAN FACE.

Ἀετὸς θαλάττιος, Græcis: Aquila marina, Latinis: Tarafrasca, Aquitanis: Aquilon, Romanis: Peſcerano, Genuenſibus: Roſſo, Illyriis Italica lingua ventibus.

—*After Belon, 1553*

FIG. 5. AQUILA MARINA, THE SEA EAGLE

THE PROBABLE ANCESTOR OF THE JENNY HANIVERS.

been added by the painter to make the thing seem more marvellous." He then speaks of it as "homo maris," a merman, and relates a story of such in the Gulf of Cadiz. His account and figure seem then to tie up definitely with the mermaid stories.

This drawing (there must have been a factory of them) is also found in various books. Thus Rondelet reproduced it in the French translation of his book published at "Lion," in 1558. So also did Conradus Lycosthenes in his "Prodigiorum ac Ostentorum Chronicum" (Basiliae, 1557), Gesner, Aldrovandi and others.

In his second book (1555) referred to above, Belon refers to a record in the annals of Brabant of a fish clothed like a bishop and having a pontifical miter on his head, but he gives no figure. In the whole matter he had been anticipated by one year by Rondelet. In this author's "Libri de Piscibus Marinis," Lugduni, 1554, we find the interesting picture reproduced herein as Fig. 3. This in many ways is more mermaid-like than is the monkfish. Its origin in Amsterdam favors the mermaid idea as does its disappearance in the sea on the Polish coast (?). Of it Rondelet writes:

> I set forth [the figure of] another monster much more marvellous, which I received from Gisbertus Germanus. This he had received from Amsterdam along with letters which affirmed that in 1531 a sea monster clothed like a bishop had been brought before the King of Poland. This had vehemently indicated by certain signs that it desired to be restored to the sea. Led thither it had thrown itself into this.

However, Rondelet was very skeptical, for he adds that:

> I have intentionally omitted many details which were told me about this monster, since I deem them fables. For it is the vanity of men, that about a thing marvellous enough in itself, they wish to add many things besides the truth.[1] I have received such a figure of this monster and reproduce it herein. Whether it is a true thing, I neither affirm nor deny.

These figures and descriptions were well known and often referred to. Thus Du Bartas in his "Divine Weekes & Workes," published in English at London in 1608, speaks of them thus:

> The mytred Bishop and the cowled Fryer;
> Whereof, examples (but a few years since)
> Were shew'n the Norways and Polonian Prince.

This is a weird-looking apparition (Fig. 3) with a very unbishop-like look

[1] How accurately this (1554) sums up the mental attitude of the average newspaper and magazine publicist of the present day (1934).

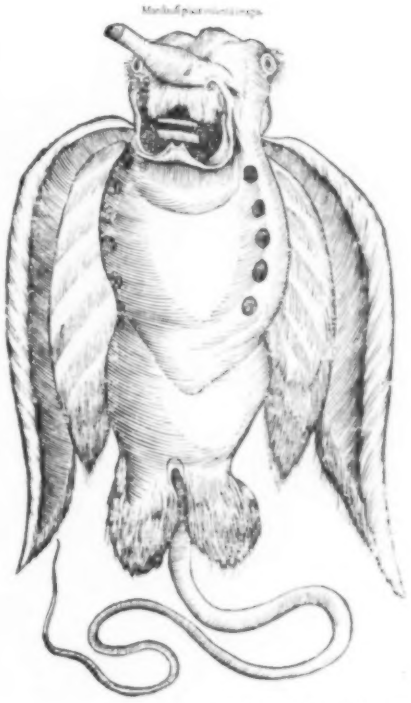
in the eye. The miter-like head-dress and the cloak do lend some credence to the name bishopfish. Furthermore, the underside of the head of some rays does offer some resemblance to that of a monstrous human face. This may be seen in Fig. 4, Günther's figure of the lower aspect of the head of a ray. Note particularly the swollen "cheeks," like those shown in Fig. 1. A fine Jenny Haniver could have been made from the ray whose face is thus portrayed.

The figure (Fig. 3) of Rondelet's bishopfish, like that of Belon's monkfish (Fig. 2) was many times reproduced in the next 50 or 75 years. But it is now time to turn to that picture which I regard as the forerunner, if not the actual progenitor, of the race of Jenny Hanivers.

Reference has already been made to the "De Aquatilibus" of Pierre Belon, published at Paris in 1553. On page 97 of this work one finds the "effigy" of the European eagle ray, shown herein in Fig. 5. This seems to have been reproduced from a larger drawing, for behind and to the left of this ray are seen the hinder parts (including tail and sting) of another ray. It is a crude woodcut, which shows the open mouth, the two tooth-plates, the pendant upper lip with the paired nostrils looking like eyes, and the pointed snout distorted to stand nearly at right angles to the head, and above and back the upper head is twisted to show the left eye.

Whether or not this was intended for a Jenny Haniver can not be positively stated, but it has been distorted in the head region and it has a certain resemblance to such a mythical monster. I believe it to be the figure which serves as a starting point from which to trace the development of Jenny Hanivers, dragons and basilisks.

This figure was also much copied and somewhat changed. Where we last find it, in Ulysses Aldrovandi's "De Piscibus



—*After Aldrovandi, 1613*

FIG. 6. IMAGE OF A MONSTER "AQUILA MARINA"
A LATER AND "IMPROVED" SEA-EAGLE.

Libri V" (Bononiae 1613, p. 437), it has plainly been much "improved" and is well on its way toward becoming a Jenny Haniver, as may be seen in Fig. 6. Among the "improvements" are the omission of the spine on the tail and the presence of two wings on each side instead of one with a notch in it. The body has one backwardly pointed transverse corrugation instead of five gently curved ones, and there are five round apertures on either side to represent the paired gill-slits not visible in Rondelet's drawing. The head is most improved: the lower lip is accentuated and the median notch has been upturned; the flat grinding teeth are better drawn; the upper lip is hairy; the left nostril only is clearly drawn; the snout, standing at

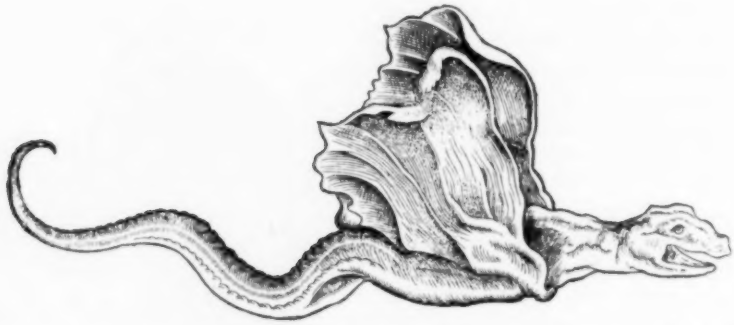
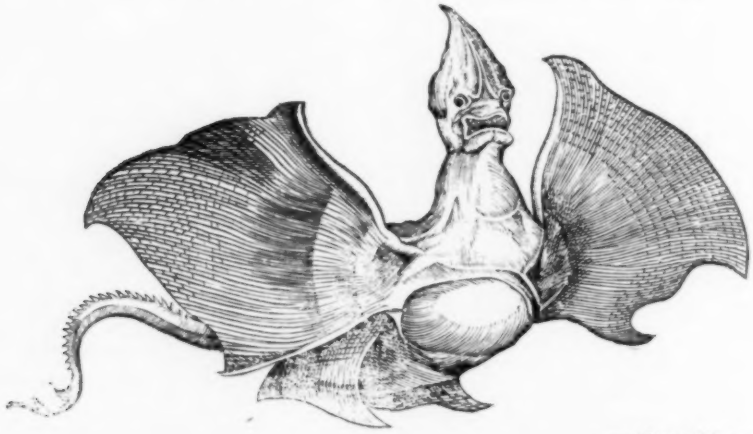


FIG. 7. A FLYING DRAGON MADE OF A RAY —*After Gesner, 1558*

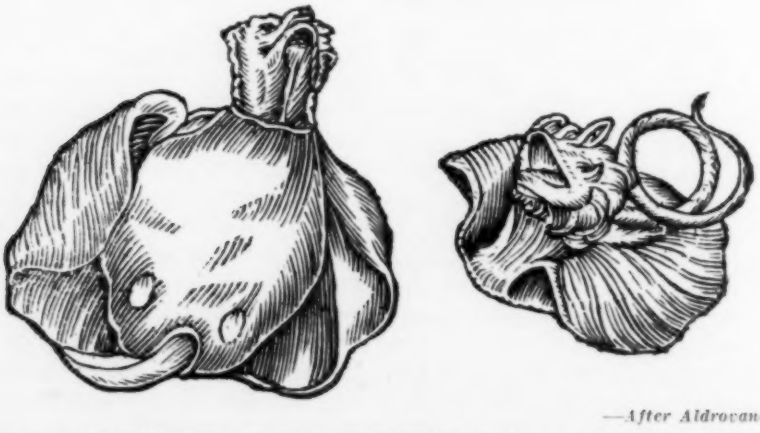
THE FINS HAVE BEEN TRIMMED AND BENT UPWARD TO FORM WINGS.



—*After Aldrovandi, 1613*

FIG. 8. "RAIA EXICCATA & CONCINNATA AD FORMAM DRACONIS"

ANOTHER FLYING DRAGON—WITH A MITERED HEAD.



—*After Aldrovandi, 1640*

FIG. 9. "BASILISCUS EX RAIA EFFICTUS PRONI & SUPINE PICTUS"

THE FABLED BASILISK SHOWN IN TWO POSITIONS.

a right angle to the head, is longer and is truncate at the tip; and finally both eyes are now visible, are supplied with eyebrows and are very staring.

Belon does not allege that his ray is a monster, but Aldrovandi does, as is indicated by the legend above its head in his figure. Belon's specimen presumably came from the Gulf of Lyons, but he states that it is found in the Adriatic Sea as well. In fact it is common in the western Mediterranean. Aldrovandi got his description of this monster from the section on monsters in the 1579 edition of the works of the great French surgeon, Ambroise Paré. Paré describes it as a fish about four feet wide and terrible and marvelous to see, having a great head, two sets of eyes, two great ears (the spiracles?), a very fleshy snout green in color, wings double, five openings on each side of the body and a long tail. Aldrovandi's drawing (Fig. 6 herein) fits the description, but seems to me to have surely been based on Belon's representation (see Fig. 5).

The Swiss zoological encyclopedist, Conrad Gesner, published his great "Historia Animalium," at Tiguri (Zurich), 1551–1587, in 5 thick folio volumes. Part four of this, entitled "De Piscium & Aquatilium Animantium Natura . . . cum Iconibus," etc., was published in 1558. On page 945 is found the figure copied as Fig. 7 herein. Gesner gives no name for this, which, however, may well be called the flying dragon. It is the first definite illustration of a Jenny Haniver known to me. This is found in "Lib. IIII" at the end of the section "De Raijs." Here follows a translation of Gesner's Latin:

> The vendors of [quack] medicines and certain others [of that ilk] are accustomed to dry rays and fashion their skeletons into varied and wonderful shapes for [exhibition to] the multitude. They also exhibit others which resemble the serpent or the winged dragon. [To make these] they bend the body [of a ray], distort the head and mouth, and cut away other parts. They take away the forward parts of the sides [the fins or wings] and raise up the remainders that they may simulate wings, and other parts they modify as they wish. I depict here [Fig. 7 herein] such a specimen as was once brought to me.

Gesner did not know the kind of ray used to produce the winged dragon portrayed in Fig. 7, but he had a very clear understanding of how it was manufactured (literally, "made by hand")—and this in the year 1558.

For our next Jenny Haniver (and the most artistic of all the old ones) we must go to Ulyssis Aldrovandi's "De Piscibus," Bononiae (Bologna) 1613, p. 443. Here we have what our old Italian encyclopedist calls the dragonfish because of its wings, but which I would also like to call the bishopfish because of the way that the snout has been manipulated to form a miter-like headpiece. It might also be called a basilisk, since it is the progenitor of a long succession of such mythical monsters—some of which will be shown further on in this article.

This Jenny Haniver, shown in Fig. 8, should be compared with the modern one portrayed in Fig. 1. Here (Fig. 8) the wings (pectoral fins) have been trimmed or manipulated to separate them from the head by smooth curves. The pelvic fins are pulled downward and probably drawn somewhat enlarged. The mouth has been widely distorted, the nostrils have been drawn to represent eyes, and the snout has been molded to simulate a bishop's miter. This Jenny Haniver is much more artistic than the one photographed in Fig. 1.

On his very next page (444) Aldrovandi has portrayed a rather crude dragon hand-fabricated from another ray. This, seen in Fig. 10, has a mouth pulled out in elongate fashion and widely opened, showing the teeth; both eyes (nostrils) are visible, thanks to bad drawing; and the snout is bent abruptly backward. The anterior fins have been manipulated to form wings, and the

—*After Aldrovandi, 1613*

FIG. 10. "DRACO EFFICTUS EX RAIA"
ANOTHER DRAGON MADE FROM A DRIED RAY.

—*After Lochner von Hummelstein, 1716*

FIG. 11. AN "OVER"-FABRICATED DRAGON OR BASILISK
THIS HAS FOUR FEET IN ADDITION TO WINGS.

hinder ones to (faintly) simulate feet, while the tail is twisted into a corkscrew.

Of these two mythological monsters, Aldrovandi gives no particular data, merely saying that "Showmen fashion diverse-shaped figures from dried rays and foist these on the ignorant either for dragons or for basilisks. I am pleased to show here two of these."

In 1640, there was posthumously published at Bologna, in folio form, Aldrovandi's "Serpentum et Draconum." Liber II of this is devoted to dragons, and at the beginning are reproduced the two figures shown herein as Figs. 8 and 10. The statements concerning them are essentially those given above. Then on p. 364, Aldrovandi figures in two positions the basilisk shown in Fig. 9. His brief statement is that this specimen, fashioned of a dried ray, was seen by the renowned Mercurialis in the treasure house (museum?) of the Emperor Maximilian. In these figures is portrayed the most contorted and crudely drawn specimen found in the old books.

The next of these artificial monsters discovered in this search is the remarkable object portrayed in Fig. 11. This was found among the curiosities collected by B. and M. R. Besler and figured by J. H. Lochner in "Rariora Musei Besleriani," Norimbergae, 1716. Lochner calls it a basilisk or a dragon, but distinctly says that it is an artificially distorted dried ray.

It is indeed an extraordinary object, comparable to Aldrovandi's dragon shown in Fig. 10. Whether the object was better finished than the other, the drawing was certainly better, as may be seen in Fig. 11. Like the former, the head parts have been much distorted and the snout forms a miter-like projecting horn; but the pectoral fins have been separated from the head and split to form anterior foot-like organs and posterior wings. The fish must have been a male, for the hind limbs seem to have been made of the claspers.

—*After Duhamel du Monceau, 1777*

FIG. 12. A MORE MODERN BASILISK
THIS ONE IS PROVIDED WITH PAWS AS WELL AS WINGS.

—From a photograph by courtesy of Mr. G. P. Whitley

FIG. 13. AN ENGLISH JENNY HANIVER

THIS IS PROBABLY NOT OVER FIFTY YEARS OLD.

Another and a very artistic basilisk is that shown in Fig. 12. It was found in Duhamel du Monceau's "Traité Générale des Pesches" (vol. III, Sec. IX, pl. vii, fig. 2), Paris, 1777. This is fashioned very much after the pattern of Aldrovandi's "dragon" of 1613 (Fig. 10), but with certain "improvements." Instead of outspread pectoral fins this "basilic" has lion-like fore-paws set at the anterior base of the pectoral fins, the mouth is much enlarged, behind the eye is a horn, the snout is twisted forward and downward into a French "liberty cap," and the wings are stayed-out by six boomlike rays. These paws are probably artificially made of some foreign material and sewed or cemented on to the body in the region where the anterior part of the pectorals has been cut away. Although but one "basilic" is figured, Duhamel states that he possessed several. He also notes that they were fabricated in various seaports by ingenious men and offered for sale as "poissons singuliers"—which they certainly were.

These fabricated and dried rays were fairly common in the private museums of the seventeenth and eighteenth centuries. Thus Filippo Bonanni in his book, "Museum Kircherianum," Romae, 1709, describes one in Athanasius Kircher's museum in the Jesuits' College at Rome. From Bonanni's description, this specimen must have been almost identical with Duhamel's. Then in C. A. Calonne's sales catalogue of his Museum Calonnianum (London, 1797), there is listed this item:

—Courtesy of Mr. Walter F. Heintzelman

FIG. 14. AN AMERICAN JENNY HANIVER

HAND-CARVED AT ASBURY PARK, NEW JERSEY, IN MAY, 1929.

—*Courtesy of Mr. Howard C. Trout*

FIG. 15. AN UP-TO-DATE JENNY HANIVER—1933 MODEL

MADE IN FLORIDA FROM A GUITARFISH.

Young-maid—Normandy—*Raia clavata* Linn. This has been bent so as to represent a dragon, and has even, in this state, been figured by authors and called the Sea Eagle [Aquila marina of Belon, 1553], Fig. 4.

Since writing the above, my attention has been called to papers by the Italian writers, Forti, Ninni and Parisi, describing various basilisk- and dragon-like artifacts, made of dried sharks and rays, preserved in the museums of Milan, Venice and Verona. Probably there are others in other public and private museums in northern Italy, for Parisi states that they were manufactured in numbers in Italy during the sixteenth century. Some of these seem to have belonged to Aldrovandi's museum, and there are MS. notes of his on "Dracones," etc., preserved in the library of the University of Bologna. These figures are too numerous to add to this paper. Perhaps they can be worked up in another article later.

More Modern Jenny Hanivers

From the modern specimen from Brooklyn shown in Fig. 1, one needs seven-league boots to stride quickly to Sydney, Australia, where in 1928 the ichthyologist, Whitley, published in the *Australian Museum Magazine* an article on Jenny Hanivers. This was illustrated not merely by three of the old figures given above, but by photographs of two modern forms. That reproduced herein as Fig. 13 is the Jenny Haniver brought from Whitby, England, by Dr. R. Mead, who has been quoted above (p. 511). This has the wings wrapped tightly around it over the back, but the mouthparts are pulled out into a snout very like those shown in Fig. 1, also a present-day specimen. The other monster was made for Mr. Whitley by a New South Wales trawler. The wings are folded back across the body, but the spread of the hinder fins recalls the like in Fig. 8. The snout is very similar to

that in Belon's "Marina Aquila" of 1553 (Fig. 5), and Rondelet's "Monstrosi Piscis Volantis Imago" (Fig. 6). Whitley's figure will presently be contrasted with that of another up-to-date Jenny Haniver.

We are now come to a present-day attempt to make an American Jenny Haniver, and here is its story, sent out by the Associated Press from Asbury Park, N. J., on May 4, 1929. This dispatch in part reads as follows:

> A fish with a "human face," slightly mongoloid and a bit weird but none the less a face, is the prize catch of Julius Gabriel, cobbler-fisherman of Allentown, Pa. . . . The creature has a large mouth, the interior of which is much like that of a human's. It has what appears to be eyes properly set with respect to the mouth, and a suggestion of a nose. The broad flap of heavy flesh makes up a high forehead, suggesting an odd head-dress. Below the head and neck the body takes on the appearance of a human being with a well-developed chest. It has a long tail with spines developed along the entire length [Fig. 14].

The statement being made that the monster had been examined by scientists of Muhlenberg College, of Allentown, Pa., I got in touch with Professor J. F. Shankweiler of the department of biology at the college. One of his students, Mr. Walter F. Heintzelman, saw and photographed the fish shortly after it was taken and after the pectoral fins had been cut free from the head, as Fig. 14 shows. The fish was about 28 inches long "over all" and about a foot wide. The photographs and accounts sent me by my informants revealed the curious fact that here was an attempt by an illiterate man, who had surely never heard of a Jenny Haniver, to reproduce those made in the fifteenth and sixteenth centuries.

Now comes the latest of Jenny Hanivers—1933 model. I had thought the Asbury Park specimen the latest thing in Jenny Hanivers. My article had been finished and was waiting to be typed when Mr. Howard C. Trout of Jarvis Avenue, the Bronx, came to my office bringing the curious object por-

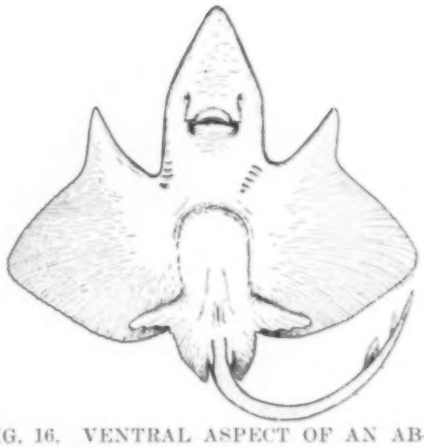
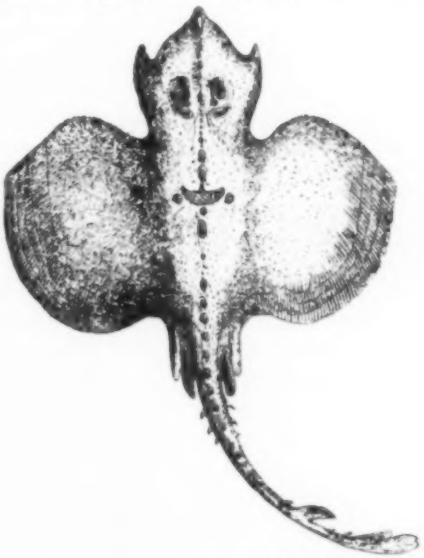


FIG. 16. VENTRAL ASPECT OF AN ABNORMAL BARN-DOOR SKATE

THIS ADULT SKATE IS A PERMANENT LARVAL FORM IN WHICH THE FINS ("WINGS") HAVE NEVER BECOME ADHERENT TO THE HEAD.



—*After Yarrell, 1859*

FIG. 17. A NATURE-MADE JENNY HANIVER

THIS HAS HORNS AS WELL AS NON-ADHERENT PECTORAL FINS.

—*After Otto, 1821*

FIG. 18. VENTRAL ASPECT OF ANOTHER ABNORMAL RAY. THIS WOULD HAVE MADE A FINE JENNY HANIVER.

trayed in Fig. 15. This Jenny Haniver is made of a manipulated, dried and painted guitarfish, *Rhinobatus lentiginosus*. Mr. Trout recently secured it at Miami, Florida, from a Swedish fisherman, who had made it some two months previously. Neither he nor any of the fishermen who looked on had any knowledge or motive other than to take the faint resemblance to a human figure and so manipulate the fish as to accentuate this.

The tip of the snout has been bent backward (or upward as the fish rests on the bottom). The double nostrils have flared wide in drying. Above them and near the rostral cartilage, eyes have been pencilled. The mouth has been pulled forward and distended. The pectoral fins have been folded back and the point of each rolled up like a scroll. The neck-region has been constricted. The appendages of the pelvic fins of this male fish have been brought together to simulate legs. And finally the tip of the snout, the neck region and the legs have been painted an orange-red.

How Nature Makes Jenny Hanivers

There are occasionally found in nature adult rays in which the pectoral fins never grow fast to the sides of the head—retaining the embryonic condition. This comes about because rays in the course of their development go through all the stages of their shark ancestors. The stage of particular interest here is that in which the pectoral fins ("wings" so-called) have not yet become adherent to the sides of the head, as is normal in rays, but remain free as in sharks. Some rays retain this as an adult character but a teratological one—*i.e.*, they remain throughout life as permanent larval forms, as may be seen in Fig. 16, a drawing of a specimen in my possession. Such rays would easily lend themselves to the making of the Jenny Hanivers figured herein, particularly Figs. 7 and 8. Three figures now to be introduced show how these and other man-made artifacts might have had an origin in nature.

In Fig. 17 is shown from Yarrell's British Fishes (3rd ed., p. 584, 1859) a

—*After Paolucci, 1874*

FIG. 19. A HORNED CYCLOPS RAY
THIS WOULD HAVE SERVED AS THE BASIS FOR A MOST REMARKABLE AND WEIRD JENNY HANIVER.

portrait of a monstrous thornback maid (*Raja clavata*). Here there are two failures of the pectoral fins to unite with the head. The first left the small lateral horns, and the second the wider notches lower down. If a Jenny Haniver-maker could have gotten hold of this specimen he surely could not have improved on nature very much. Note that this ray is figured as seen from above.

Even more weird is the ray portrayed in Fig. 18. This, the first adult ray with non-adherent wings ever figured and described, was obtained by the Breslau naturalist, Otto,[2] from a fisherman at Edinburgh, in 1818. Otto did not recognize it as an abnormality, but thought it a new kind of rayfish and gave it new generic and specific names. The round form of the under surface of the head, and the conformation of mouth and nostrils give it a rather human appearance, while the remnants of the pectoral fins somewhat resemble ears or perhaps hands in that position called for in the present-day oft-repeated command—"Hands up!"

Weirdest of all is Paolucci's horned and cyclops-eyed *Myliobatis noctula*[3] (Fig. 19). It is something wherewith to scare children and even grown-ups. The short horns and the sinister single eye of this monster between them, with the broad mouth below, combine to produce an apparition the weirdest and most abnormal in my collection of figures of such teratological rays. Its specific name, *noctula*, indicated that it went abroad only in the dark—as it surely should. From it could have been fabricated a most marvelous Jenny Haniver.

[2] Paolucci, Luigi. Atti Soc. Ital. Sci. Nat., 1874, vol. 17, pp. 60–63, figs.

[3] Paolucci, L. Atti Soc. Ital. Sci. Nat., 1874, 17, 60–63, pl.

RULING THE RIVER

By REGINALD D. FORBES

In his pioneering plans for the all-around development of the Tennessee Basin and other valleys, President Roosevelt has stressed the importance, as a first step, of practising forestry in the mountains. The ancient Japanese proverb, "To rule the river is to rule the mountain," evidently appeals to him as good common sense, in spite of the scepticism rampant in some American scientific circles as to the existence of any appreciable influence of forests upon the flow of our streams. This scepticism has found vigorous and often acrimonious expression in the press, and has at times threatened to develop a major controversy between professional men and among public agencies.

That the President's views are based on first-hand knowledge of the forest is apparent from a story told by the secretary of the Society of American Foresters. A summer or two ago the New York section of the society visited the Roosevelt estate at Hyde Park to see the forestry operations under way there. After their inspection of the woods the foresters were invited to meet the governor informally on the lawn of Krum Elbow. To their delight his welcome was not a perfunctory five-minute speech, confined to generalities, but an illuminating twenty-minute discussion of some of their professional problems. It showed such evident grasp of a specialized subject that a cynic in the crowd whispered to the state forester beside him: "Which one of you foresters wrote the Governor's speech for him?" A few minutes later the official addressed, thinking the joke too good to keep, repeated the question to Mr. Roosevelt. Whereupon the governor, with a twinkle in his eye, turned to his attendant. "Sergeant," he said, "what did I ask you when we came out on the terrace half an hour ago?" The man grinned. "Why, Governor, you said to me: 'Sergeant, what the devil am I going to tell these boys?'"

Early Controversies

The belief that forests exert a favorable influence on stream-flow was first publicly expressed in the United States in connection with the acquisition and administration of the national forests. Only 70 of the 150 million acres set aside in such forests from the public domain of the West bear commercial timber. The remaining 80 million are, nevertheless, given protection against fire and excessive grazing, because of their location on the watersheds of streams having enormous value for irrigation and other purposes. By those who see nothing in the conservationists' claims this has been described as a great waste of public funds. For example, a former chief of the Weather Bureau has said: "For years an extensive propaganda has been carried on in the United States for the purpose of inducing large public appropriations not only to protect the real forests of the nation, which every right-thinking person wishes to have protected and wisely conserved, but also millions of acres of bush lots and scrub timber that can never grow anything of value. The reason given by forest enthusiasts for such expenditures is that this otherwise worthless vegetation protects the water supply of great centers of population. But I know of no scientific reason to justify their claims." The foresters' arguments in favor of a beneficial influence of forests on stream-flow to him seem "—the hysterical screams of interested office-holders who

"TO RULE THE RIVER IS TO RULE THE MOUNTAIN."
SCENE FROM A FORMERLY FIRE-SWEPT MOUNTAIN, NOW PART OF THE ALLEGHENY NATIONAL FOREST, PENNSYLVANIA.[1]

wish only to retain their jobs of protecting worthless vegetation. They hope so to alarm honest people with forebodings of impending disaster that large grants of public money will be forthcoming to increase their personal emolument and hire additional defenders."

In spite of this early opposition within the Department of Agriculture itself, public opinion has not only sustained the National Forest system, but has also enlarged it. The Weeks Act, passed in 1911, authorized the purchase of lands for national forests in the East, where little or no public domain still existed, and specified that such lands be "located on the head-waters of navigable streams or those which are being or which may be developed for navigable purposes." The Clarke-McNary Act, which, in 1924, superseded the Weeks Act, prescribed that in future purchases "due consideration shall be given to the protection of watersheds of navigable streams, but—may be—extended to any timbered or forest-producing lands or watersheds from which water is secured for domestic use or irrigation." Several million acres have been added to the national forests under these two acts.

[1] Photographs by courtesy U. S. Forest Service. California photographs by W. C. Lowdermilk and P. B. Rowe.

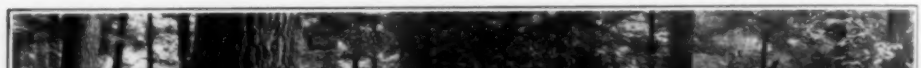
FORESTS AND THE MISSISSIPPI FLOODS

The Mississippi flood situation has been another occasion for the published expression of widely divergent views on forest influences. In 1925 an army officer of high rank compared records of precipitation over a portion of Wisconsin, on the headwaters of the great river, with the flow of streams there, from the time when the virgin forests were still intact down to 1924. He concluded: "I maintain that land, cleared of timber and gone back to scrub—is equal to, if not greater than, the original forest in reducing run-off. As more of this land goes under cultivation the run-off will be less. This brings me to my early theory that farms are better than forests in re-

ducing run-off." The same officer, as chairman of the Mississippi River Commission in the year of the worst disasters in the history of the river—1927—announced that "*after exhaustive studies* covering the advantages and limitations of reforesting, reservoirs, cut-offs and outlets, as steps toward reducing flood heights, it was decided that levees afford the *only* practicable means for flood control in the lower Mississippi Valley." (The italics are mine.) Subsequent commissions have but slightly and grudgingly modified this view.

Very different were the conclusions reached by the Department of Agriculture after a Forest Service investigation of the 1927 flood. Without denying in the slightest degree the necessity for engineering works in the control of the river, Secretary Jardine reported that ". . . the forests of the Mississippi watershed were responsible for a reduction in the possible flood crest of nearly 15 inches. Furthermore, were all the forests of the Mississippi Valley properly protected and managed in accordance with established principles and practises, a further reduction in possible flood crests of 55 inches would be possible. Thus the results, even when based on acknowledged incomplete and conservative data, are of such significance that it does not seem possible that the part the forests play in the control of floods can be longer ignored."

If a foot—or six feet—on the crest of a stream having a flood depth of a hundred and fifty feet seems rather trifling, be it remembered that it is the last few feet that bring destruction and terror to the lowlands. No one who has ever stood on the levee which protects his home and has watched the inexorable rise, inch by inch and hour by hour, of the brown waters bringing disaster and perhaps death, can ever belittle the last few feet of that rise. It may be, indeed, that no levee ever gave way at the top, but it was the weight of the final flood crest that caused its collapse.



IDEAL PROTECTION AGAINST BEATING RAINS.

THE HUMUS IS HALF A FOOT DEEP BENEATH THIS VIRGIN HEMLOCK FOREST.

GUARDIANS OF THE TENNESSEE WATERSHED.
A MOUNTAIN HARDWOOD FOREST.

FOREST INFLUENCES A COMPLEX PROBLEM

How can such divergent views be held among scientific men? How can some deny to the forest any influence at all upon stream-flow, and others as stoutly maintain that the influence is great? Essentially, it is because the relationship is an extremely complex one, and because under the great diversity of physical conditions in the United States generalizations from limited or local information are rarely possible. Approached from single angles, the problem yields many answers. That is why the experiment stations of the Federal forest service, in studies only recently begun, have attempted to subdivide the problem and to dig down to fundamentals in its solution. Some of the still fragmentary information already gained by them is the chief basis for the statements in the remainder of this article.

The behavior of any stream—whether it is steady in flow throughout the year, or now in flood and a few months later dry—depends on three things—the climate, the geology and the vegetation of the region from which it flows.

Of the climatic factors, precipitation, mostly rain or snow, is of course all-important. In a country as large as the United States there are enormous variations in yearly precipitation. The valleys of southern California are populous, in spite of a yearly rainfall of less than ten inches. At the very summit of the Blue Ridge in the Carolinas and Tennessee the precipitation is 80 inches, and on the western slopes of the Cascade Mountains in Oregon and Washington the yearly average is 120 inches. The low California rainfall is largely concentrated in a single rainy season, whereas the vastly more abundant rain or equivalent snow of the two mountain regions is rather evenly distributed through the year. The behavior of the streams of these regions inevitably reflects these differences in total and seasonal precipitation.

The quantity of rain or melted snow which soaks into the soil of mountain slopes, to reappear, often months later, at the surface as springs and streams, is dependent on the depth and porosity of the soil, and on the character of the underlying rock. In shallow soils the quantity of stored water may be very

CANYON FILLED WITH SEDIMENT FROM SINGLE STORM OVER BURNED WATERSHED, SOUTHERN CALIFORNIA.

THE SAME CANYON BEFORE STORM.

slight. But in most regions the water slowly moving through the soil is infinitely greater in quantity than that stored above ground in lakes and ponds. Underground storage has the great advantage over surface storage that it is not nearly so subject to evaporation. In southern California, for example, where fully 80 per cent. of the water for irrigation is pumped from underground storage basins at considerable depths, the evaporation from a water surface greatly exceeds the yearly rainfall, whereas from a bare soil it may be only 50 to 80 per cent. of the rainfall.

Degree of slope has been rather unexpectedly found to have little influence on the rate at which precipitation soaks into the soil, although it has a very profound effect on so much of the water as, unable to penetrate the soil, runs off over the surface.

The first two factors—climate and geology—which influence the flow of streams are for the present at least beyond human power to control. But the third factor—vegetation—man has it in his power to alter and even destroy. Through such agencies as axe, saw, fire and the excessive grazing of domestic animals the people of the United States have tragically altered the vegetation of the greater part of our vast territory. We have cleared the original vegetation, either forest or prairie sod, from some 500 million acres needed for agriculture, and, as we are only now beginning to realize, have done a very indifferent job of replacing it with an artificial vegetation equally capable of preventing serious washing of the soil. Erosion of farm lands has been characterized by the United States Bureau of Chemistry and Soils as a national menace. Another 400 million acres, not needed for agriculture, we have not only stripped of its virgin timber, but have also permitted in greater part to burn over, thereby reducing a once magnificent vegetative mantle to a pitifully thin one. We have not even spared the woodland, the chaparral, the sparse herbs and grass of the drier parts of the country, but have ravaged them with fire and in places all but exterminated them with over-grazing by our domestic animals.

The Rôle of Forest Humus

The result of these actions of ours can best be understood from a knowledge of how the undisturbed forest affects the flow of streams. First and most important of all, the forest decreases the proportion of rain and melted snow which runs off over the surface of the ground. Water which sinks at once into the soil and reaches the streams by slow percolation, being held temporarily in the myriad spaces between soil particles and in the crevices of rocks, rarely causes erosion, and perhaps never causes disastrous floods.

Why rain beating upon bare soil is not readily absorbed has been clearly demonstrated by a simple laboratory experiment of Dr. W. C. Lowdermilk, of the California Forest Experiment Station. He filled tall glass jars with soil, and allowed clear water to percolate downward through the soil columns for several hours. The rate of flow was very constant, and undiminished with time. He then muddied the percolating water with some of the fine surface material typical of these soils. Within six hours the rate of flow dropped to 10 per cent. of what it had been. The fine soil particles, carried downward in suspension, had clogged the pores of the upper soil layers, and permanently ruined the absorptive capacity of the soil. Dr. Lowdermilk points out that rain beating on an unprotected soil is inevitably muddied, and, acting like the muddied water in his jars, promptly renders the soil beneath impermeable.

If the ground in question is flat, the water simply accumulates on the sur-

YESTERDAY A TORRENT, TO-DAY A TRICKLE.
PROTECTIVE VEGETATION EXTERMINATED BY SMELTER FUMES. TENNESSEE.

face. But if the ground slopes, it rushes down hill, eroding as it goes, and swelling even normally tiny streams into torrents. Thus the Southern Station, working on the upper watershed of the Tallahatchie River in Mississippi during the great Yazoo Delta floods of two years ago, found that in the heaviest rains 95 per cent. of the water ran off the surface of cultivated land, protected only by the stubble of the previous season's corn crop. During a ten-week period an average of 62 per cent. of all rain ran off the surface, carrying with it 34 tons of soil an acre! The surface run-off of summer rains from more permeable soils in Wisconsin was found by the Lake States Station to be about 25 per cent., in spite of the protection afforded by a growing crop of corn or other grains.

In strong contrast with the soil of clean-cultivated fields, the ground beneath a dense forest is never bare. It is carpeted by a layer of fallen leaves, twigs and other plant material in all stages of decay—forest humus. Until recently the chief rôle of forest humus in preventing rapid run-off was believed to be its capacity for absorbing water. Humus will absorb three or four times its weight of moisture; in a hardwood forest, such as that of the southern Appalachian Mountains, this absorption under favorable conditions has been found to equal a quarter of an inch of rain. But this effect on run-off is probably quite insignificant when compared with the ability of humus to keep falling rain clear, and thereby to allow its uninterrupted passage into the soil beneath. In the Mississippi and Wisconsin studies just referred to *less than 3 per cent.* of the rain ran off the surface of forested land. Recent experiments at the Cen-

tral States Station have demonstrated that water sinks much faster into the naturally loose, humus-covered soil beneath a forest than into the artificially loosened soil of adjacent fields.

But this is not all that forest humus does to promote storage of water in the soil. Acting as a mulch, it retards evaporation. Again, the fine particles of humus, carried downward by percolating water, enormously increase the moisture-holding capacity of soils. Five per cent. of such material will increase the water-holding capacity of a coarse sand by 40 per cent. The humus derived from dead roots has the same effect.

Other Factors in Forest Influences

The major influence of the forest on streamflow is unquestionably exerted by the humus. But there are other important influences. For example, a very substantial proportion of the rain falling on a forest is prevented by the leafy crowns from reaching the ground. Have you ever taken refuge from a shower under a tree? You then know that a light rain may be completely intercepted by the dense foliage of some tree species. The Pacific Northwest Station found this to be true in a mature Douglas fir forest, and that of an entire summer's rainfall over a third may be intercepted in the crowns. In a dense sapling stand the percentage intercepted is even higher.

Again, evergreen forests have been found to delay the melting of snow in the spring. In those parts of the United States where snow accumulates to depths of several feet, and particularly where snow is the important part of the year's precipitation, the rate of snow melt is doubly important. If the snow melts all at once, and before the frost is out of the ground, floods cause havoc, and much precious water fails to reach the underground storage basins for summer use, generally the irrigation of farm lands. Although the total accumulation of snow may be less under a forest canopy than in the open, due to interception of the falling snow by the tree crowns, late in the spring a substantial amount remains there a week or two after it has disappeared from open ground. Because the spring thaw, once begun, is rapid, this brief delay permits much of the winter's precipitation to be absorbed in the ground, instead of running off the surface.

Melting is delayed partly by the shade of the tree crowns, but probably more by the lessened movement of drying winds. In a northern Idaho valley a full stand of western white pine and larch reduced the wind movement during the fire season to only one twenty-fifth of that in a logged-off area adjacent. Evaporation within the forest was in consequence only one sixth of that in the open. Reduction of evaporation of course means that once precipitation has entered the ground more of it will eventually find its way into streams.

Below ground, the dead and decayed roots of forest trees form channels for the penetration of water into the soil, and by adding to the invaluable humus content promote water storage. On the other hand, living roots withdraw vast quantities of water from the soil. The water taken up by the roots is carried up to the leaves and combined with carbon dioxide from the air to form plant food, under the influence of sunlight. In the process water is transpired into the air. C. G. Bates, of the U. S. Forest Service, experimenting with potted 5 and 6-year old seedlings of Rocky Mountain evergreens, reported that to produce a gram of dry substance these seedlings required an average of 880 grams of water. But the water transpired by an entire forest of mature trees is impossible to measure by any such laboratory experiments as those used in the study of seedlings weighing a few grams. Even European foresters have made

nothing more than estimates, which place the annual loss by transpiration from temperate zone forests at 10 to 50 per cent. of the rainfall.

Regional Variations Important

The net effect of all these influences of the forest upon streamflow will obviously differ from region to region and from season to season. Under all conditions the nearly complete prevention of surface run-off by a dense forest and heavy humus is enormously beneficial, because of lessened soil erosion. Its corollary—increased absorption and storage of precipitation in the soil—fails to be wholly beneficial only in so far as the stored moisture is transpired into the air by the trees, instead of contributing to the dry-season flow of streams. The same is true of retardation of snow melt.

Whether the interception of rain and snow in the tree crowns, their absorption by the humus, and their return to the atmosphere through transpiration, are beneficial or detrimental depends upon the region and to some extent the season. In the southern Appalachians, with their normally high and well-distributed rainfall, generally deep soils and steep slopes, floods appear to result from a succession of heavy storms separated by short intervals of fair weather. Under such conditions all the factors which operate to reduce the amount of water reaching the streams after each storm combine with the prevention of surface run-off to make the forest indispensable to well-regulated streamflow. The President is on particularly strong ground when he insists that forestry be practised on the headwaters of the Tennessee River. The annual loss from floods, many of them on this stream, in the state of Tennessee averages $1,000,000 a year.

But in a region of relatively low rainfall, concentrated in a rainy season, reduction in the total run-off caused by forest or other vegetation is distinctly detrimental, and to be tolerated only if offset by the favorable influences of the forest. Southern California is such a

APPARATUS FOR MEASURING SURFACE RUN-OFF AND EROSION. SOUTHERN CALIFORNIA.

MEASURING EFFECT OF DENUDING FORESTED SLOPES, CALIFORNIA.

region. Here water for irrigation and even domestic use is of vital concern, the available supply limiting the further development of an otherwise rich region. Only recently, studies of precipitation and streamflow records, chiefly from this region, have led engineers of the U. S. Geological Survey to question "whether the value of increased water supply and better-sustained minimum flow which are shown to obtain without forests, does not outweigh the benefits of lowered normal flood flows and decreased erosion produced by forests." Foresters have replied that the chaparral, or "elfin forest," which covers 97 per cent. of the southern California watersheds, and which, as they have demonstrated, minimizes surface run-off and erosion, prevents only a very small amount of water from reaching the streams. During the season of greatest rainfall it intercepts almost no rain and is not actively transpiring, being leafless. The cottonwoods, willows, sycamores and alders of the canyon bottoms, on the other hand, although occupying but 3 per cent. of the area, are tremendous users, all summer long, of the water which concentrates in their habitat from the surrounding hills. Fortunately it is a comparatively simple matter to pipe the water around the canyon groves, and thus save it for human use. As for the fact, pointed out by the engineers, that burning off the hill vegetation increases the summer, or low-water, flow of streams, records show that even the increased flow is less than 5 per cent. of that for the entire year.

What Is Needed

Quite evidently what America needs in the conservation of her enormously important water resources is not more controversies, but more facts. The foresters' studies, backed by Old World experience, have already established the general fact that forests improve streamflow. But very specific knowledge is required by engineers who design storage dams, plan flood control works and devise stream improvements. Such knowledge may be gained only by further research in which all the complex factors of climate, geology and vegetation are evaluated. To this end engineers, meteorologists, geologists, soil experts, botanists and foresters must join hands.

LANAO—LOVELY LAND OF ROMANCE

By Dr. ALBERT W. C. T. HERRE

CURATOR, MUSEUM OF ZOOLOGY, STANFORD UNIVERSITY

"ROMANCE, romance, romance," runs the refrain in a popular song of yesteryear, and so beat the heart throbs of countless millions of people in every land. The overwhelming majority of men and women, boys and girls, of every tongue and every clime, crave something outside the humdrum of their everyday existence. They long for something unknown, they know not what, and impute to the little known, the bizarre, the exotic, strange esoteric qualities that are the very quintessence of romance. The city lights lure thousands, but others are attracted to ice-capped Antarctica or the unexplored jungles of New Guinea, where cannibals and birds of paradise enliven the forest.

Not all realize that romance exists as well in the test tube and retort and casts its purple glow across the bacteriologist and microscopist. It is apparent in the study of electricity and in the work of the field naturalist, whether botanist or zoologist, while even the man in the street knows that romance is an integral part of the life of the geologist and anthropologist.

Through all the ages people have seen adventure and romance wherever alien tongues, strange customs and different religions prevailed. When these are placed in a setting of tropical jungle, with its strange enormous plants, dazzlingly brilliant birds, teeming insect life, gigantic snakes and chattering monkeys, people of northern climes are ready to believe almost any fantastic yarn.

The East Indies are a typical region of romance. For untold centuries adventurers and hellions of all sorts have gone there as pirates, merchants, missionaries (Hindu, Buddhist, Mohammedan, Christian), conquerors, wonder-seekers, and so on. Hindus, Cambodians, Siamese, Chinese, Japanese, Arabs, Portuguese, Dutch, Spanish, English, all explored, traded, raided, looted, converted, while among themselves the Malays did the same and more. Great empires arose, only to fall centuries later in that world of islands, and the commerce of all nations paid tribute to the pirates of Illana Bay and Tawi Tawi down to the memory of living men.

That northern spur of the East Indies which we call the Philippines is one of the most interesting of all the island groups. Its highly varied population includes the Negrito with no permanent habitation, the Manobo and Ilongot tree dwellers, and all grades of society up to the cultured and cosmopolitan graduates of great American and European universities who would ornament any social circle.

For many years I have been intimately acquainted with one of the most intriguing portions of the Philippines. It lies in Mindanao, that great island known to white men for more than four hundred years, but still containing unexplored areas and a wealth of life offering rich fields for scientific investigation.

The area to which I refer is the mountainous plateau of Lanao, one of the "Moro" or Mohammedan provinces. This region has a reputation for "battle, murder, and sudden death," but in reality is as safe as cities in the United States.

Lanao is in the west central part of Mindanao. Its north coast is bathed by Iligan Bay and it extends southward to Illana Bay, a part of the Sea of Celebes.

Most of the province, which has an area of 2,722 square miles, is a mountainous plateau, with a very narrow fringe of coastal lowland.

The mere tourist carries from Lanao memories of brilliant sunshine, interspersed by daily thunder showers, nights of refreshing coolness, and withal a colorful bizarre glimpse of strange people living about a great jewel-like lake in a setting of lofty forested volcanoes. But Lanao is worth far more to a scientist than merely a two- or three-day visit. At the risk of too much detail, let us note some of the attractions of Lanao.

The dominant feature of the region and the one that gives its name to the province is Lake Lanao. Lanao is the Marinao word for lake, and either as danao or lanao occurs in many Malayan languages. Lake Lanao is therefore a redundancy, but I see no way to avoid using the term. The lake is a fine open expanse of clear water, covering 145 square miles and lying at an elevation of 2,100 feet.

To reach the lake one ordinarily lands at Iligan on the north coast of the province. From here an excellent automobile road ascends to the lake. As the sea coast is left one is almost sure to see a family group of monkeys crossing the road, which skirts a deep and heavily forested canyon. At the head of the canyon a brook leaps down about 400 feet, forming a small but very lovely waterfall.

Gaining the plateau, one travels over rolling hills, denuded of trees and sprinkled with the small farms of the natives.

As one climbs the last ridge and enters Camp Keithley he is impressed by the wide open spaces and the unobstructed view across the lake and beyond. Villages on the eastern and southern shores, ten to twenty miles away, are plainly visible. Then leaping over a few miles of intervening low land, one's eyes rest upon the lofty volcanic peaks of the Butig range, which rise to an elevation of over 9,000 feet and are clothed to their unexplored summits by the densest sort of primitive dipterocarp rain forest.

Between Camp Keithley and Dansalan, the provincial capital, is the outlet of the lake, the furiously rushing Agus, which races and roars, leaps and tosses madly in headlong speed to the sea. Not far from its mouth the Agus makes a

VIEW OF LAKE LANAO FROM THE GROUNDS OF THE LUMBATAN FARM SCHOOL

plunge of 65 meters over the precipice at the head of a box canyon, forming the picturesque Maria Cristina Falls.

The present province of Lanao was originally a coral reef which later was raised a few hundred feet above the sea. Upon this ancient reef, lava flows and great deposits of volcanic ash were superimposed.

Lake Lanao was formed when a deep mountain canyon was dammed by a lava flow. Gradually the mountain torrent thus checked filled the gorge and in time spread over the tableland eastward, thus creating the present lake. Not far from the outlet I found a depth of 150 feet in the lake, and at the head of the ancient canyon the military cable survey found a depth of 900 feet. This was near Bayong, on the southern shore. Over most of its eastern half Lake Lanao is comparatively shallow, and thousands of acres near the eastern shore are covered by only two to five meters of water.

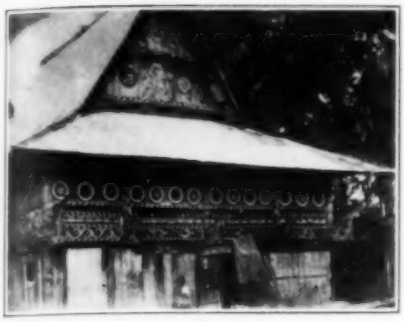
Lake Lanao contains a unique and highly interesting fish fauna, which I discovered some years ago while making a reconnaissance of its aquatic life. I have thus far described seventeen species of Cyprinidae from the lake. They belong to four different genera, three of them new.

These seventeen species of Cyprinidae are all descended from a single parent species, which is found all over Mindanao and throughout Malaysia west of Lombok and Celebes. Elsewhere I have discussed this remarkable demonstration of evolution here and now.

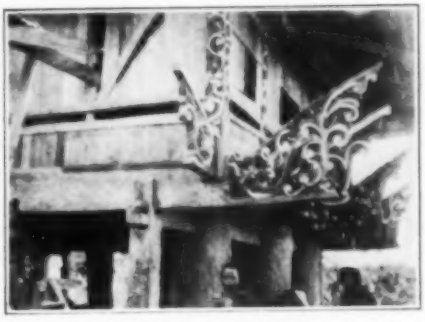
In addition to the above, Lake Lanao contains an eel (*Anguilla celebesensis*) and one species of Ophicephalus (*Ophicephalus striatus*). The latter was introduced by man long, long ago, as I have shown in the case of several other lakes.

Eels of the family Anguillidae breed only in the deep sea far from land. Their presence, therefore, in the lake is

IN A MARINAO VILLAGE ON THE EASTERN SHORE OF LAKE LANAO.



HOUSE OF A MARINAO DATU.
NOTE THE CARVED ENDS OF THE FLOOR JOISTS WHICH ARE HEWED PLANK SOMETIMES THIRTY OR FORTY FEET LONG.



CLOSE UP OF THE ELABORATE CARVING CHARACTERISTIC OF THE HOMES OF WEALTHY MARINAO. THE INTRICATE DESIGNS ARE CHISELED IN THE HARD WOOD.

rather puzzling. When the young elvers enter the coastal streams from the sea it is manifestly impossible for them to ascend any with a waterfall such as the Maria Cristina. Careful observation of the talus slopes along the canyon walls below the falls reveals the presence of many streamlets and gouts of water spurting from the cliffs at the top of the talus. I believe that the young eels climb the talus and creep through these water-bearing crevices, to emerge in the river well above the falls.

As already pointed out in *The American Naturalist*, the cyprinid fishes of Lake Lanao offer an unexcelled opportunity to the student of evolution, particularly to those who desire to make statistical studies. Needless to say, the lake also presents a nearly virgin field for the hydrobiologist who is really desirous of studying aquatic life of all kinds under almost ideal conditions.

For a totally different kind of an environment, let us land at Tamparan, on the eastern shore of the lake. Three hours of steady walking through the rice fields will bring one to the edge of the cleared land, and before long the last homestead will be left behind. From then on there is only the unbroken primitive forest extending to the other side of the mountains. At first one sees where rattan gatherers have been at work or some one has taken out a tree for some special purpose, but gradually one draws into the sort of jungle that grows only where almost daily rains stimulate the growth of vegetation, and practically all trace of man disappears. The single trail crossing the Butig mountains is rarely traversed. When I saw it last it had almost disappeared from view and was nearly impassable from windfalls, landslides and the rapid growth of tropical plants. Rugnan, at the summit of the pass at an elevation of 5,000 feet, is said to be the coldest spot in the Philippines.

This great forest and its untrodden volcanic peaks hide many botanical treasures as yet undiscovered. Deer and wild pig are plentiful, and often at night one may hear the death squeal of a luckless shoat as some gigantic python snatches him up from the ground. Family parties of monkeys roam freely through the intertwining tops of the great trees, or scamper madly away from the deadly swoop of the swift and powerful monkey-eating eagle, perhaps the largest and strongest of his tribe. One rarely sees any of the beautiful birds concealed in the world of light atop of

the trees, but now and then in the gloom of the forest one is thrilled by a rippling burst of song from some invisible bird. It is high up in the trees, too, that the great land snails, with their lovely shells, are found.

On the ridges south and southeast of Lake Lanao, especially those looking down on Lake Dapao, grows the largest bamboo in the islands. It is a delight to wander in the shade of giant clumps of this Brobdingnagian grass or traverse the dim aisles formed by its eight-inch stalks arching sixty to ninety feet above. On the wild trail to Lake Nununñgan, sprinkled amid the gigantic wild bananas, is an undescribed pandan which strides on its impossible looking stilt roots across the dripping wet mountain swales and rears its flamboyant head fifty to eighty feet above the earth.

During the greater part of the year there are land leeches in all the forests, whether on the slopes of the Butig mountains, on the Nununñgan trail, or southward down to Malabang. Land leeches are very, very slender liver-colored creatures about an inch long, always hungry, and very active in the pursuit of prey. To watch countless numbers waving their blind heads to and fro as they stand erect and try to locate possible prey, or see them go looping their way unerringly toward approaching animals, is a shivery experience. Fortunately, if one dresses properly, *and is sufficiently vigilant*, he can avoid their attentions. It is pitiful to see them distended with blood and looking like bunches of grapes hanging around the ankles of barefoot porters or on the fetlocks of horses. Once in rainy weather I thought to avoid them by riding horseback, but to my astonishment beautiful longitudinally striped green and gold leeches dropped from the trees above and promptly proceeded to levy tribute.

Near Bayong the tourist sees enor-

A RIVAL WAR PARTY AT MASIU

READY TO FIGHT OVER THE SUCCESSION TO THE SULTANATE OF MASIU. THE AMERICAN AT THE RIGHT OF THE CENTER IS MR. C. O. DOUGLAS, TEACHER AT LUMBATAN.

A WAR PARTY ASSEMBLED AT MASIU IN 1925.
NEARLY 200 HEAVILY ARMED MEN WITH A MARVELLOUS AGGREGATION OF BLADE WEAPONS WHICH THEY WERE ACHING TO USE.

mous leafless trees covered with strange-looking, large, pear-shaped "fruit." I once overheard a party of American and Tagalog tourists arguing about this fruit. When I told them the fruit was merely gigantic fruit bats they were very skeptical until a shot caused them to take flight. These fruit bats have a wing spread of three to five feet and fly with the slow labored flight of a tired crow, instead of the erratic swift flight familiar in other bats.

Since "the proper study of man is mankind" the Marinao, as the people of Lanao call themselves, would well repay careful investigation.

The Marinao are undoubtedly of the same general stock as their neighbors, the Bukidnons and Manobos, but were converted to Mohammedanism a long time ago, probably in the fourteenth century. The advent of the new religion brought a higher culture, and the slight but definite contact with Arabia maintained through all the succeeding centuries by those making the pilgrimage to Mecca has emphasized and strengthened their advance above the surrounding pagans.

The Marinao, secure in their mountain fastnesses, were always a turbulent and independent breed, as touchy as Gaelic or Southern Appalachian clansmen. As a result they never developed a strong government or a central authority. Datus, or hereditary chieftains, are very numerous and there are several petty "rajahs" and four "sultans." No Spanish grandee was ever more conceited over his lineage than are the Marinao aristocracy, who trace their ancestry back to the "Arab" adventurers who brought them Mohammedanism.

The homes of wealthy Marinao are notable for their unusual architectural decorations. The floor joists, made of very hard wood, project several feet beyond the building line. The free ends are then very elaborately and intricately carved. In addition, the walls are usually more or less artistically decorated. The carved ends of the joists strikingly resemble the elaborate carvings on the vintas of the Samals of the Sulu Archipelago, and are unquestionably a survival from ancient seafaring days.

The Marinao excel in brass work, some

of their betel boxes, inlaid with silver, food containers and ornamental vessels being of very unusual design and possessing real artistic merit. Agongs, as they call brass gongs, are of various sizes and are a form of portable wealth much esteemed. Old agongs of historic or legendary fame are valued at extraordinary and utterly unreasonable prices. Many of them are very sweet toned. Agongs have a therapeutic value, according to the Marinao; when a person is sick the agongs are beaten to drive away the devils that cause the illness. If they are sounded long enough the patient either gets well or dies. If the former, it was due to the virtue of the agongs, but if the latter it was because the devil was too powerful.

Marinao women are expert in making mats, of handsome and distinctive patterns and colors. These mats are used for beds. They are also skilled weavers and from their crude looms come very handsome cloths of mixed silk and abaca. Their malongs, as they call the East Indian sarong, and head cloths are not only strong but brilliantly beautiful as well. A Marinao dandy in full regalia is an imposing sight, with his bright flowing garments and wide, silver-mounted hat. The carrying of kampilans, as the great two-handed native sword is called, krisses and death-dealing spears is now contraband, and the Marinao men are no longer picturesque walking arsenals.

But hidden away in Marinao homes are still many, many blade weapons. In 1925 Mr. C. O. Douglas, supervising principal at Lumbatan, and I went with Lieutenant Diokino of the constabulary to see what we could do to avert a battle between two rival factions who were at war over the sultanate of Masiu, a position not yet vacant, for the sultan was still alive, though very old. The two groups, each numbering about 190 men, assembled at the southeast corner of the lake soon after daylight. The defenders of the existing régime gathered about the great house of their datu, shown in the picture. Those clamoring for a new deal swarmed in and about a cota, or native fort, about half a kilometer away.

For over three hours fighting threatened to start any moment. The first kris brandished would have been the signal to cut down the meddlesome peacemakers. Had we been armed or shown alarm we would have been cut down at once. About 10:30 our reinforcements arrived, 25 raw constabulary recruits, trembling with fear, but in charge of four seasoned sergeants and corporals. The tension eased somewhat then, but it was 2 o'clock before the warring factions withdrew simultaneously.

It was a great experience, for there was displayed the most wonderful aggregation of blade weapons imaginable. Every man carried a kris and most of them had kampilans and daggers as well. They had not only the characteristic Lanao-made kris and kampilan, but weapons from every part of the Malay world and the route to Mecca—heirlooms and weapons famed in Lanao song and legend, many generations old, and weapons that were part of the loot of piratical raids from Pinang to the Aru Islands; weapons with carved ivory or elaborate golden hilts, blades inlaid with silver or encrusted with gold, weapons that would make the heart of a collector ache with envy; even the poorest were silver mounted. Most of the men also carried silver-mounted spears with tremendous razor-edged blades and shafts of palma brava, every one a museum specimen. In addition each side could also muster about forty guns and revolvers of almost every make, all strictly contraband and most of them of no value, except as curios.

The social organization of the Marinao people is amazingly like that of our own ancestors some generations removed. A hair-trigger, clannish people, dirty, ignorant, but of keen intelligence withal,

hospitable but suspicious of outsiders, they have the faults and also the virtues of a Gaelic clansman.

A wealthy datu in his great house lives like a minor feudal lord. His wives, children and immediate retainers, whether freemen or slaves, live with him and make up his little circle. Life is a curious mixture of despotic authority and the most democratic freedom, but that is true of practically all Mohammedan communities. The datu is bound to protect his retainers and give them food and shelter if needed. In return they till his land, do his bidding and follow him to death if need be.

The Marinao respect a good fighter and will acknowledge the supremacy of the leader who defeats them in battle and then treats them exactly as promised. But they are ever ready to take advantage of those who vacillate and will go to any extreme to revenge themselves upon those who evade or break a promise.

Our ideas of Mohammedanism, with the veiling of women and their seclusion in the harem, are derived from Turkish or Arabic sources. Like all wide-spread religions, Mohammedanism has adapted itself to the customs of the country. The veiling of women in India, the Near East and northern Africa preceded Mohammedanism and is a heritage from the remote past. But amid the teeming millions of Malayan Mohammedans there has never been any veiling of women and little or no seclusion. The Marinao woman, therefore, takes her place in the community on a nearly equal footing with men, just as women of all creeds do all over the Philippines.

The characteristic structure of Marinao society is rapidly being destroyed. The great piratical datus of the south coast of Lanao vanished years ago, and the desperate fighters of Bayong have been vanquished, their cota, unconquered for a hundred and fifty years, captured and dismantled.

Twenty-five years ago the Visayan sakayan that ventured too near the coast of Iligan Bay was captured and its unlucky crew killed or made captive. A few years ago there was not a house on the coast between Iligan and Kolambugan. To-day coconut plantations reach more than half way from Iligan to the great lumber camp of Kolambugan, and the region is no longer a place of dread. The lumber camp has been a potent factor in effecting change, too, since about half its horde of workers are Marinao from the far-off hills remote from outside influences.

The automobile road now extends along the west side of the lake, and a dirt road extends on to Lake Dapao. It is only a matter of a very few years until there is a good automobile road all the way down to Malabang on the shore of Illana Bay. A good road means that the outlaw and cattle lifter can no longer raid with impunity and then escape to his hills. (How like the whole thing is to the cattle raids our Scottish ancestors pulled off "Across the Border.") A good road also means that the Marinao will travel about more readily, be reached more fully by outside influences and will respond to changes in the great world beyond Lanao with comparative rapidity.

A few years more and the Marinao will become standardized in the regular Filipino pattern, or else be exterminated. There should be a happy compromise between the two which would ensure them their full development. No matter what happens, studies should be begun of them right now, before it is too late.

There is still a fine opportunity for the exploring botanist to add materially to our knowledge of Philippine plants and their distribution by exploring the slopes of the Butig range. The rich insect fauna is practically untouched, and little is known of the other invertebrate life of the region, whether aquatic, terrestrial or arboreal. Even the birds and

reptiles have not been carefully studied, while as stated before the fishes of Lake Lanao offer a field for the investigation of certain aspects of evolution that is probably not equalled by any other locality yet explored.

Life for the naturalist should be pleasant at Camp Keithley or any other place where he might establish his base in Lanao. His work would inevitably assume the aspect of a delightful vacation amid beautiful surroundings. If it did not also assume the purple and rose of romance it would merely be because he had mistaken his vocation. It would be inexpensive, too, for a little money goes a long way in Lanao. Americans, Christian Filipinos and Marinaos alike would cooperate with him in his explorations. To the naturalist who desires to take up a practically virgin field amid surroundings entirely different from anything he has ever encountered before, and which have a many-sided appeal, I can not wish for anything better than a few months in Lanao.

PELE'S MOODS!

By Dr. G. R. WIELAND

DEPARTMENT OF PALEOBOTANY, YALE UNIVERSITY

In Ferdinand V. Hayden's U. S. Geological Survey Report for 1872, geologist F. H. Bradley notes overhead sounds about the Yellowstone Lake—not reaching musical pitch, however. Nextly these sounds, shortly after described as resonant or metallic rather than musical, were frequently heard about the Yellowstone country in July–August, 1890, by Professor Edwin Linton, then of Washington and Jefferson College, Pennsylvania, and Stephen A. Forbes, of the State Natural History Survey of Illinois, Urbana. Linton and Forbes were then making a biologic survey of the park waters for the U. S. Fish Commission, and both shortly recorded their very unusual experience. Forbes' note on the sounds was given in the *Bulletin* of the U. S. Fish Commission for 1891, published April 29, 1893, while Linton gave an interesting account of the phenomenon in *Science* of November 3, 1893 (pp. 244–6).

From that time on the marvelous aerial acoustics of the Yellowstone get singularly scant note for years. Even the guide-books, gotten out with all that avid, arid thirst for the ultra-wonderful, are silent! Except that in General Chittenden's "Yellowstone National Park" (pub. Cincinnati, 1915), the "acoustic phenomena" are given direct mention.

On July 30, 1919, Hugh M. Smith, then at the head of the U. S. Fish Commission, heard the rare sounds while fishing from a canoe near the outlet of the Shoshone Lake at its southern end. He noted that the sounds seemed augmented when the canoe motion was quickened and the line held by a bamboo rod became taut. Apparently in still water the curved sides and bottom of the canoe acted as a sort of sounding board, tending to focus the overhead sounds. But the description of the sounds later given in *Science* (June 11, 1926, pp. 586–7) varies from earlier accounts. The sounds are now noted as "musical, of rare sweetness, rich timbre, and a full volume increased by the noiseless surroundings." So great was the astonishment that "one was all but prepared to see a pipe organ suspended in midair." Duration was from ten to fifteen seconds, and was later thought to range in pitch from below center C to even above tenor C of the pianoforte, the tones "blending in the most perfect chromatic scale."

Nextly, in *Science* (July 30, 1926, pp. 586–7) Forbes, noting Smith's communication, again briefly mentions the sounds as he and Linton heard them on the Shoshone Lake and at the Yellowstone Lake in 1890. He too is surprised that so little note or attempt at explanation has been given the sounds; Linton comes back to the subject in *Science* (January 24, 1930, vol. lxxi, pp. 97–9) quoting his original notes of 1890. The sounds were then heard July 23, August 4, 8 and 9, being first noted at the upper (western) end of the Shoshone Lake by boat about 8 A. M. Heard best, the sounds rather indefinitely reverberate in the sky with a slight metallic resonance; or again they are like a mixture of sounds as of wind in trees, telegraph wires, echoing bells or humming of bees, etc.—all making an easily recognized sound which would be easily overlooked where there were many noises. Forbes notes too that ranger naturalists record the phenomenon from Grebe Lake, near the cañon of the Yellowstone, and that in the "Ranger Naturalist Manual" for 1928 a summary is given by Ranger Marguerite Arnold. And with these forewords may I now record a personal experience of thirty-two years ago?

On September 8, 1902, walking through the pines alone by direction, and the day being clear and still, I reached the western shore of the Shoshone Lake. As I strolled down over the sinter slopes of the Geyser Basin, and amongst the hot water kettles near the lake edge about 11 o'clock of the morning with quite enough of self-sufficiency and vanity perhaps, a sudden burst of intensely musical sound swelled for some seconds through the air above me and as if somewhat out over the Lake, rolling away to be lost in the distance. The effect was absolutely startling. Nothing in my young life had ever prepared me for anything quite like that! At first I thought of some camp unnoted and sounds like some great accordion or Jew's-harp, or bagpipe. But only gnarled trees were in sight, and the cadence had distinctly seemed to proceed from some moving source overhead, gaining in volume as it neared, and fading away in the distance. Then followed an awareness that the sounds had lasted long enough to bring a futile response as if to avoid or evade them or have them stop! Next there was some sort of inadmission of fear and dare to the inexplicable. A mindedness that was set, and "from Missouri!"

The manner in which the sounds changed as their source seemed to move easterly was striking in the extreme. Linton especially notes the break of more musical notes as heard about the Shoshone into reverberations or explosive noises usually passing to the southwest; and he thinks he may by chance be mistaken in a note recording disappearance easterly. I also heard curious reverberations and little explosions following the musical tones. These seemed to continue for some seconds off to the east, as if moving along the shore out of sight from one to two miles away. The effect was odd, not quite like the sound of fire arms, nor yet of thunder; and it seemed too uneven, too little located to have come from any camp. It made the musical sounds even more mysterious. The reverberations seemed to pass far out over the lake. Thinking back, taking the rate at which sound travels into consideration, it would seem possible that although the musical cadence was heard first it might or might not have been preceded by the explosive phase. On following days, about the Heart Lake Geyser Basin and in climbing Mount Sheridan, I noted no further sounds.

My purpose in scouting round the outlying hot springs and geyser basins was to observe firsthand any evidence for initial stages of petrifaction, or cellulose replacement by silica or calcium carbonate. The notes then made have held high interest ever since. It was seen

that there was considerable infiltration going on as woody materials slowly disappeared. Pine needles found in the hot water kettles at the Thumb of the Yellowstone Lake seemed completely replaced. But the general impression gained was that the conditions favoring more perfect types of replacement, were mostly hidden from view, where heat and some pressure might aid in the breaking down of cellulose by orthosilicic acid. Some minor laboratory experiments recently made confirm the impression that cellulose is very resistant to change, even in the presence of silicic acid. But undoubtedly the optimum conditions for opalization can be determined in a course of simple experiment.

It is much to admit; but I can't recall that I even mentioned those sounds or more than vaguely held them in mind, until I read my friend Dr. Smith's account and learned for the first time how slow might be my own response to what was outside all ordinary experience. No less, I had yet to learn something further of the psychology of utter surprise and of ignorance. By chance I chose a wooded valley set in the hills near the Little Sebago Lake in Maine to await the total solar eclipse, August 31, 1932. Obliquely opposite lay a long rising lateral thick-wooded swale. This, as it turned out, was set just right for the writhing play of colors often noted as an eclipse begins or ends. The scene was picturesque in the extreme. There were heavy clouds near, and there was just enough of a haze to ruin the outer corona, the inner, however, showing fairly bright. Just as a great Bailey bead flashed out and the shadows rushed on, that swale seemed a swaying, tempest-torn, moving Birnam wood. Such was the singular effect of the color play. Having seen the colors in very different light on the snow (eclipse of January 24, 1925) did not help. Once more there was an instant of intense surprise, though it thus became evident that the eye (as before the ear) had really caught the extraordinary. For once more the sudden, uncontrolled secondary reflex, even defining fear, asked cessation! Only this time all was set in memory.

From Marco Polo's singing sands down, aerial sights and sounds have surprised and caught unaware all humans. They have led to superstition and to poetry. Thus in *Science* a fine essay on the musical sounds has been given by Professor Henderson of Yale (September 26, 1924, pp. 282–83). And one might well recall some of the imagery of the German poet Uhland.

> Man höret oft im fernen Wald
> Von obenher ein dumpfes Läuten
> Doch niemand weiss von wann es hallt,
> Und kaum die Sage kann es deuten

Evidently there may be more of the remoter natural sounds by far than the texts admit. One might speak of the *near* sounds, or echoes, and the *far* sounds or those of more recondite source. Multitudinous sounds may approach the musical, though the ordinary sounds of the hills or mountain sides are dissonant. Consonance, with vibratory volume being mainly physical or mathematic, must be a rare phenomenon—one so outside knowledge that it would be missed entirely amongst the sounds of ordinary life and fields. The primitive man hears the sounds, sees the sights of the lonely places and peoples the air. Thus the intelligent Hawaiian lady at the Bishop Museum has told me something of Pele. About Halemaumau, the name meaning, "the fern house," she dwelt. In anger she rose above the storm, the lavas flowed, and the fern forests were a sacrifice to her; though they soon grew forth again.

Quite the most extraordinary of all nature sounds accompany the Aurora. And as these sounds would have a physico-chemic cause, and come in the sun-spot cycles, day or night, the question might well be raised whether the sounds of the Yellowstone are in part or in any sense also cyclic and coincident or connected. The sounds of the Yellowstone, as reported, or as heard just locally, do not seem as continuous as the auroral sounds of the high North.

But there is certainly a degree of similarity. The question is whether auroral sounds may also reach musical cadence.

In *Science*, for September 8, 1933, Clark M. Garber relates his experience while crossing the mountain range bordering the Arctic coast north of Cape Prince of Wales on the Bering Strait, during a fine aurora of the winter of 1925–1926. At midnight, as the display took on the drapery effect, audible sounds like "crackling from fine jets of steam" continued for some time. This I must believe exactly correct; though, as it chances, it is the first time I have ever heard the subject broached, or noted it on printed page. Reading for a general description, I find I missed all paragraphs on auroral sounds!

As usually stated, the audible aurora is not heard in our latitudes. About eight o'clock on the evening of March 22, 1920, a telephone call from a near neighbor advised me at my home near the Oyster River, Connecticut, that what shortly proved to be the greatest auroral display of our neighborhood for this century was on. I rushed back into our meadow as the great draperies, yellowish rather than of other or high color, were sweeping close before from out of the north. The drapery or curtain form was sublime, amazingly close. From within it there welled out a very distinct volume of sound, perhaps like some close-by shower or fine threading sizzling rain. Or taking that simile further. From the Chuska front on the western edge of the San Juan basin I have sometimes watched a thousand feet through of rain storm in the making. If all those swaying sheets of rain had been masses of infinitesimal threads emitting a thin, boiling wave of sound there would have been simulated somewhat the auroral sounds I heard while getting into position for more carefully noting an amazing moment. But just then the draperies seemed to dissolve into a second phase which I watched from the roof of my house far past midnight, as a silent display of threading light and oriented cloud effect.

As Professor Schlesinger, of Yale, has explained to me just now, the "rustling silk" sound attributed to the aurora of the high north must be very similar to what I heard, as also to some of the sounds described from the Yellowstone. And the neighbor, Mr. Joseph H. Roseberry, who telephoned, now says he and his son Hugh believed they too heard a sound, much as I did. So far, however, it is not understood that such sounds are musical, as Dr. Smith (quoted above) heard them at the Shoshone Lake, and as I heard them there in quite the same tenor.

Strange, strange, as before in the Yellowstone eighteen years earlier I discounted my impressions as merely the impossible. But I am not wrong, and just as I now at last learn that the Eskimo hear the aurora, so I am sure that yet others may recall that in our latitude where brilliant display is rare, they heard that of March 22, 1920. And if these sounds are of a physicochemic source, may not some of the sounds of the Yellowstone have a similar nature or even be partly auroral?

Recalling as above, Dr. Smith heard the musical sounds at the outlet of the Shoshone Lake in almost identically the same manner as I did six miles due west at the Geyser basin; except that he noted the sounds firstly from his canoe, while I heard them ashore. From this fact it may be inferred that the sounds often pervade the air, perhaps to a considerable height over the surface of the entire lake and its adjoining shores. Hence in the complete absence of synchronous observations at different points it is difficult to see how the primary explanation of the sounds as a purely vibrational effect due to deeper thermal or explosive

activity may be a sufficient one. Have the Yellowstone aerial vibrations on the contrary some chemic, or radioactive source? May one imagine some form of interception of rays from without as a cause of areal atmospheric sound—sound occurring over large areas in a highly characteristic tone?

Certainly the auroral sounds scarcely come from the high altitudes of fifty or sixty miles where the visible effects appear. In any case here is a significant series of facts about which next to nothing quantitive is yet known. Slowness of observation is much due to the near impossibility, in all casual notation, of recognizing true aerial sounds in any but the lonesome spots of earth—those of the high altitudes or within the arctic areas.

Since the preparation of the foregoing notes there has just appeared in *Nature* (December 2, 1933, p. 385), a short account of auroral audibility, and the "low Aurora" by Messrs Davies and Currie of the Canadian Meteorological Office, Toronto. They give the experiences of the Canadian Polar party near Chesterfield Inlet on the west shore of Hudson Bay. The testimony of Esquimaux and others is very variable; but both whites and Esquimaux probably hear low swishing sounds which are auroral, not subjective. Maximum audibility is in the region of maximum auroral frequency.

That there is indicated some form of audible ray reception, or atmospheric ionization effect, or even both combined, must be held true of the Aurora. It is evident too, that there is dissimilarity between the *low* and the *high* Aurora. While the phenomena of the former certainly invite comparison with what may occur in a region as active physico-chemically as is the Yellowstone.

Notes on sound phases of volcanism, especially those precedent to renewed activity, mostly lack a comparative form. Could such be transmitted by radio, or given more exact record? But these sounds much resemble those heard about the Yellowstone in more subdued tenor. The burr of the Castle geyser before play is cited, and the merely general comparison I may make. In May, 1907, the year before the destruction of Messina, I climbed the ash cone of Etna in the darkness of early morning, reaching the summit before sunrise. Midwinter conditions as it seemed yet held, and the inner edge of the crater could only be seen in patches as strong winds momentarily tore away the thick curtain of mist and solfatara gases. Climbing to the edge of the cone meant taking a little of chance, and one could only remain there for a minute at a time, owing to difficulty in breathing. The mountain was well understood to be growing active. A tremendous resounding burr of component sound rose from the crater depths.

INTELLIGENT PLAN IN NATURE, EVIDENCE FROM ANIMALS[1]

By Dr. MAYNARD M. METCALF

Is there evidence of intelligent plan in nature, or is all due either to chance, or to purely mechanical outworking of relations in the primordial substance or force or whatever it is that is the ultimate existence? This question is, of course, one of interpretation and not to be answered by scientific description.

There is much in nature which suggests design. Apparently from very early times men have so interpreted isolated natural phenomena. At first they saw "spirits" in all the natural world, spirits at least mildly malevolent, if not violently so. Men's constant thought was of propitiating the spirits in earth and air and water, in sun and moon and stars, in trees and rocks and mountains, in beasts and birds and fish, in storm and lightning and earthquake. Nothing happened by chance or by mechanism; everything was purposeful, however capricious the purpose. The universe, as men knew it, was peopled by a multitude of demons, little demons, big demons, petty mischievous demons, fearful devastating devils, and all conscious of man, whose chief concern was to propitiate them so that at least they might leave him alone.

In time good spirits were added to the devils, and angels fought with evil demons. But still man had no thought of any comprehensively consistent relations underlying the seemingly capricious phenomena about him. This conception has evolved slowly with the progress of science, and is yet to many minds not clearly defined. The Greeks and Romans, the Chinese and the inhabitants of India, the Mesopotamians and Persians and Egyptians, all thought of nature as controlled by gods without any unified purpose. Even "monotheism," with its good god in control of his angels, and more powerful than the bad god with his devils, hardly brought men's philosophy of nature to the point of belief in harmonious unity. Daimonology still ruled the common man. Gods, angels, devils and saints constantly influenced men's welfare. Until rather recent times all men have believed, and without question, in purposeful control of natural phenomena.

But, especially during the twentieth century, there grew a new school of thought, which rejects intelligent plan and purposeful action in nature. In its extreme form, a group in this movement rejects, even for man himself, the reality of intelligence or purpose, all this sort of thing being unreal and delusion. This philosophy recognizes unity in nature, but no intelligence or design. Unintelligent mechanism, on the one hand, and capricious, daimonic control, on the other, are the two extremes. Both extremes seem beyond acceptance. What middle ground can the ordinary man find on which to found his life? What view of the universe in which he lives may he take?

We have set ourselves a difficult question, but not one which is beyond profitable study. Let us approach it in the scientific spirit, rejecting no class of natural phenomena, physical or spiritual, which are capable of being tested and so are within the scope of scientific treatment. We will limit the inquiry to data furnished by animals.

[1] A chapter from an unpublished symposium volume upon intelligent plan in nature, written by thirteen men of science in England, Scotland, Germany, Canada and the United States.

Many persons limit the word scientific to physical phenomena and relations, denying that spiritual (*i.e.*, personal) phenomena can be tested by the scientific method. I believe, on the contrary, that spiritual phenomena are as capable of scientific testing as are physical phenomena. The method is the same for both kinds of data, although the criteria of reference, of measurement, in the two are very different.

What is the scientific method? It is observation, hypothesis, deduction and experimental testing. The student of physical science observes certain phenomena, perhaps unfamiliar phenomena, and after repeated observation and careful thought upon them and upon known phenomena which seem to be related to them, he forms an hypothesis which seems to be consistent with all the known data. He then ruminates over the hypothesis to see what necessary implications it may have. Then he tests the validity of the hypothesis by testing one or more of these necessary corollaries, if he can devise satisfactory experiments for this purpose. If he can not find a way to put the hypothesis, or some of its necessary corollaries, to experimental test, he realizes that the hypothesis is unproven and must be classed as speculation until satisfactory indication of its validity shall appear.

The student of spiritual, personal, phenomena uses identically the same methods. The only difference between the students in the two fields is in their criteria of reference, the measurements they use. The physicist uses grams, meters and seconds. The student of spiritual phenomena uses the test of harmony with nature, as shown by the increased spiritual power which results from following spiritual hypotheses that are in harmony with the Whole, or the diminished power which results from disharmony. The tests in the two realms are equal in validity, but those in the personal field require more time to get the readings, for they are a matter dependent upon growth.

If we observe animate nature in its broader relations, one of the things which most impress us is the adaptation of plants and animals for the lives they live in the midst of their surroundings. A fish, with its stream-lined form, its posterior propeller, its lateral oars, its nose and eyes at the anterior end of the body where they give notice of what the fish is approaching, its swim-bladder to counterbalance its weight, its gills for water-breathing, and, in fact, all its organization, shows adaptation and shows peculiar fitness for life in the water. A bird shows even more striking adaptations, especially those which enable it to fly. Its air sacs and its hollow bones filled with warm gas give it buoyancy. Its wonderfully constructed and interlocked feathers are, even in minute details, peculiarly adapted for flight. Thousands of sorts of insects and mollusks and worms show adaptations which fit them for the lives they live. The one-celled animals, even those so small as to be almost invisible, show equally detailed and remarkable adaptations. Adaptation, fitness for the lives they live, is a well-nigh universal character of living things and is shown in many of the minutest details of their structure and of the most intimate features of their physiology and behavior.

It is true also that the adaptations change as the animals change from one kind of life to another. Fish have swim-bladders which make them less heavy in the water, but they do not use them for breathing air, except that the lung-fishes, more highly evolved forms, do swallow air into their bladders and use it to assist slightly in aerating the blood. The frogs start life as fish-like tadpoles in the water and breathe by means of gills like a fish. Later, at the time of metamorphosis to adult frogs, they leave the water and become terrestrial; at this time the organ which in the fishes was a swim-bladder develops into a true lung with its very thin walls richly supplied with blood-vessels. Higher vertebrates, which have no aquatic life, pass beyond the condition which is adapted for life in the water while they are still in the embryo stage and they have functional lungs from the beginning of their active lives. The same organ, differently developed in different animals, is thus first a swim-bladder and later a pair of lungs, but in each condition it is adapted for the use to which it is put.

This principle of change in adaptation is illustrated in probably every

organ in the higher animals. In man, for example, I can think of no organ which was not once in a different condition and adapted to serve an at least somewhat different purpose. The mammalian heart began, as in a lowly relative of the vertebrates, Amphioxus, where it is a mere tube which contracts in waves from behind forward and so pushes the blood along. In fishes the walls of the tube thickened and developed chambers separated by one-way valves, making it a more efficient organ for propulsion of blood. But still in these gill-breathers all the blood takes but one course, going first to the gills to be aerated and then to the body to carry oxygen to it, allowing the cells to breathe. In air-breathing vertebrates, which get their oxygen through lungs, the heart and its connected blood-vessels are completely divided to form two streams, one connected with the comparatively feeble right half of the heart, which propels the blood merely to the lungs and back to the heart. Returning this time to the heart, the blood enters the much stronger left side, which pushes the aerated blood along a much longer course to all parts of the body, except the lungs, and back to the heart, ready to start again to the lungs. But in all the stages of the evolution of the heart, from the straight tube in the ancestors, through the undivided heart of the gill-breathers, on to the double heart of the lung-breathers, the structure has been sufficiently adapted to the needs of each organism to serve it effectively.

One of the most noteworthy series of changing adaptation in a single set of organs is that which has given us our organs of smell, taste, balance and hearing. Beginning as pointed cells scattered irregularly over the skin, as in Amphioxus, they have developed into the grouped sensory cells of all the organs named, and probably also into feathers and hairs. Adaptation, growing more perfect and more diversified, characterizes evolution throughout.

Not only adaptation and change in adaptation, but, even more, parallelism in adaptations, are impressive, and such parallelism is, perhaps, especially significant. The marsupial mammals, the group to which the opossums and the kangaroos belong, are not closely related to the other mammals, yet we find that they have used many similar adaptations to fit them for the lives they live. There are, thus, wolf-like marsupials, rodent-like forms and others which resemble insect-eating higher mammals.

But as conspicuous an example of parallel evolution as we could well find is seen in the eyes of the highest mollusks, the cuttlefishes, and in those of the vertebrates. The eyes of the two are built upon the same mechanical plan, a firm-walled eyeball containing a retina with sensory cells and pigment, a partition across the eye separating an anterior from a posterior chamber (open to the exterior in the mollusk), a central opening in this partition and a lens in this opening, and several other remarkable detailed resemblances. But the two eyes are fundamentally different. One develops from the skin of the head. The other arises in part from the skin, but chiefly as an outgrowth from the internal, nervous tube from which the brain and the spinal cord also arise. The retina in the vertebrate eye is inverted, with its sensory cells turned away from the light, turned inside out, as it were. But the molluscan retina is undistorted, its sensory cells being directed toward the light, as is, of course, the natural arrangement.

The cuttlefishes are no relatives of the vertebrates. The eyes of the two are wholly unrelated, and in both embryonic development and in evolution their eyes have followed wholly different routes, but they reach a final result which is the same in the remarkable, elaborate, me-

chanical adaptations by means of which these eyes function. The keenest imagination is wholly unable to follow the course of the evolution of an organ so intricate as the eye of man. It seems almost beyond belief. But for two eyes, in unrelated organisms, to start in different portions of the body and, by very different series of changes, to reach a structure fundamentally the same functionally, even in great detail, yet wholly different morphologically, is fairly flabbergasting. The wildest imagination could not invent such things. One stands dumfounded in the presence of such phenomena.

This all surely suggests plan, purpose,[2] in nature. But, if so, it is not a single, stereotyped plan and a limited purpose. Charles Kingsley, in that delightful book "Water Babies," makes the good fairy, Mother Cary, say "Know, silly child, that any one can make things, if they take time and trouble enough; but it is not every one who, like me, can make things make themselves." And this may be the key to the infinite diversities of adaptation in nature, there being as many artists engaged in designing adaptations as there are living things to share in the use of them. All animals and plants are engaged in fitting themselves better and better for the places in which they live and the very diverse things they have to do. Mother Cary's method of having each work at the designing, so that there are as many artist-artisans as there are individuals, is infinitely clever and makes coworkers of them all.

Of course, not all individuals, nor all kinds of animals, are well adapted; and the ill-adapted perish in the end. Not only is this true; there are even strong trends in some animals toward evolution in disadvantageous directions. Many species, genera, families and larger groups of animals have become extinct because of such obstinate insistence upon developing into increasingly ill-adapted structure and physiological habit. Examples are the huge, prehistoric reptiles, who kept on evolving great bulk until their alimentary canals could no longer feed them, bulk increasing in cubical dimension, while the digestive and especially the absorptive lining of the alimentary tube, which prepares and gives them all their food, increases chiefly in surface dimension and is ultimately swamped by the impossible task placed upon it by the great body.

No intelligence in animals themselves saves them from destruction. If they keep within the limits of serviceable adaptation, it is through an automatic self-regulation, and our question is whether this masterful self-regulating system in nature is due to Mother Cary's wisdom or to chance. It is not only animate nature we must consider, but inanimate nature as well and the way the two interact.

Recent concepts of the universe seem to be reducing it all to force. Matter, substance, according to those who hold these views, is as outworn an idea as is that of a world of indifferent or malevolent demons. A bit of matter, a stone, for example, is conceived as a congeries of discrete, though not unrelated exercisements of force. We think that a stone is not solid, but that there are spaces between its atoms, and spaces between the electrons and protons, the atomic nucleus and the possibly considerable variety of entities within the atom; and there is even lurking suspicion in many minds that the atomic nucleus itself may prove to be a little universe of great complexity. At any rate, we conceive a stone as containing much more of empty space than of substance. And all which we might possibly think of as substantial, the protons,

[2] Purpose seems too limited a word. It is the fundamental organization and character of the universe itself, without which the universe could not exist, which is intended in the word, the trend, the direction of all existence in its most fundamental aspect.

electrons, neutrons, atomic nucleus, etc., are themselves, in this type of thought, resolved into bits of force.

Thus our universe, as we at present conceive it, seems to be resolved into force present as discrete exercisements whose salient features are not all quantitative (space and time relations), so far as we can judge, but are in part qualitative (electrically positive or negative).

If, therefore, force[2] be all, however complex and diverse its manifestations, whether as rock or plant or human being, our question with which we started seems to be, "Is the force, which is all there is, itself intelligent and purposeful, or is it controlled by something other than itself which is intelligent and purposeful in its exercising of control, or is it all blind, mechanical, with nothing of intelligence or purpose?" I can give only my own feeling as to this question and some of the reasoning which leads me to the conclusion which has been for me the acceptable one.

I find no evidence in favor of conceiving of two distinct entities, a force which is the universe, and something besides the universe, which controls the universal force; though such conception would not affect our search for intelligent plan in it all. I have no quarrel with the man who prefers the dualistic conception. The indications of intelligent purpose are the same in each case. But to me the universe itself is either intelligent or unintelligent, purposeful or lacking in purpose, personal or mechanical, just as a man is intelligent, purposeful and a person, or is lacking in these qualities. Is the universe a person, God, if you will, or not? Man is no less a person (if he be a person, *i.e.*, not an automaton) because he has a physical body which can not be called personal either in its several parts or as a whole.

Our question, "Is nature personal?", which is essentially the same as "Is there intelligence and purpose in nature?", suggests that we look into the matter and see if we find intelligence and purpose. As we have said, the wonderful and well-nigh infinitely diversified adaptation seen in nature might well suggest plan. And the fact that we find in living nature a method of self-regulation, which brings about adaptation, does not necessarily halt our further search by relegating all to mechanism. Let us look further.

In nature itself we find, beyond all question, as it seems to me, purpose, force, personality. Man is a part of nature, and man possesses intelligence. His acts we directly know to be sometimes purposeful; and we know directly that we exercise power toward the attainment of our purposes. We have direct knowledge, in ourselves, that man is thus a person, a person with capacity for appreciating beauty, goodness, honor, faith, faithfulness, all of which are aspects of beauty, and he is capable of feeling the urge, the compulsion of beauty. Intellect, sensitiveness to qualities, as well as sensitivity to quantitative stimuli, power to choose and power to endeavor in the line of his choice—a person.

If such a bit of nature, built up by nature in her growth, has the inexpressibly great and valuable qualities inherent in personality, can it be otherwise with nature herself? Can the part be infinitely greater, qualitatively, than the whole? To me the very asking of the question is its answer. Of course nature, which made man and comprehends man, is no less worthy, is no less beautiful than man and his possibilities.

Man is able to reveal himself to other beings who have souls and so can appreciate man's personal revelation. Similarly, nature can reveal her soul, God can reveal his personality, to other beings who have souls to receive the revelation. The extent of the possible

[2] Note that force, not energy, is the word used.

revelation is measured by the breadth and the depth of the recipient. This is the confession of faith of a humble follower of science, to whom the endeavor to view all phenomena honestly has indelibly impressed the spiritual phenomena of personality, the overwhelming importance of the personal. To me the spiritual is primary, the physical derivative from the spiritual, not only in worth and purpose, but also factually in causation. I have felt my will acting on my body, and through my body producing physical effects. This causation is more than antecedent and consequent. It is real, vital, personal, in myself, and it is effective force. With the ever-present urge toward unifying underlying relations, I cannot but feel that the physical and spiritual are essentially one and that the spiritual aspect is primary, the physical its outworking; in other words, that God's will sustains everything and that all is directed by intelligence and is purposeful. And this conception of the universe as intelligent force I get from animals, especially from that animal which I am.

The only idea we have of essential causation, an antecedent containing compulsion so that the result has to follow, comes from the fact of our wills exercising such compulsion. To be sure, our will may be successfully opposed; but the fact of the compulsion we know, and its at least occasional success in producing effective result we observe, and it is from this attempt to produce result, an attempt we directly feel in ourselves, that the whole concept of cause comes. Our volitional act may be, as it were, a catalyzing agent, releasing energy stored outside itself. The measurable energy of any resultant activity is not the same as the volition, but in the volition is found the instigator of the series of physical phenomena which follow. And there may be, of course, a train of spiritual results following our volitional act, which are no more measurable by physical measurements than is the act of will itself. Without this experience of volitional urge and the resultant phenomena, all our thinking would be in terms of mere sequence. The whole concept of force would then be absent. It would never have entered our minds to construct the idea of cause, if we had not had experience of cause inside ourselves, experience of force, of effective force; and this force which we experience is our own, is personal.

That this animal which I am has the capacity to comprehend the whole in its plan and purpose is, of course, unthinkable; still there is one more question arising, which will not down—"If purposeful, what is the purpose? If nature has a trend in its fundamental being, what is the direction of that trend?" Hopeless as any adequate answer is, still one can not refrain from dreaming. What we may find of purpose is doubtless but faint adumbration of the breadth of the whole, but, if we are made in God's image, that is, are consistent products of nature herself, our concepts, though infinitely limited, may not be utterly false. To me, and I can not speak for any other, creation, growth, and, as the highest I can conceive, growth of beauty, and especially of that beauty which inheres in persons, is the most restful, most satisfying aspect I can conceive of what may be nature's purpose. Growth is one of the most fundamental characteristics of living things, possibly the most fundamental. If nature be alive, if God is alive, apparently there must be growth, and growth including its culmination in spiritual beauty.

Thus in animals, in man, we find the evidence of intelligence and purpose in nature, and in our sense of beauty, in the dominant, controlling influence of beauty upon our spirits, we find a suggestion of an apparently sufficiently great purpose for nature, the purpose of the exercise and growth of that person who is nature and of creating[4] persons

[4] By evolution.

who shall be centers of growing beauty[5] I was asked to discuss the evidence of intelligent plan in nature, as found among animals, doubtless for the reason that I have been a student of animals. I have, however, confessed the inadequacy of such evidence if man is not taken into the picture. But man is in the picture, very much in the picture, and man is an animal, a product of nature. In him, just as truly as in an amoeba, or a rock, or a star, she reveals herself; and man, as a person, with his intelligence and his capacity for purposeful action, is a part of nature's self-revelation. The question put to me to discuss is philosophical, but it is natural as well. Man is natural. I do not believe there is validity in any essential distinction between natural and supernatural. Man's capacity to appreciate beauty and duty is as natural as any other part of him. His capacity for experience of natural religion, for appreciation of the beautiful, for following the urge toward the beautiful, for recognizing the consequent duty to seek the beautiful, including beauty of conduct, his capacity for moral conduct, all are natural and, as such, are to nature means of self-revelation. The best in nature is as natural as are her physical aspects, and, as I see nature, her spiritual (personal) aspects are those which reveal her most intimately, tell of her purpose, make legitimate the search for answer to the question "Why?" as well as to the question "How?" Man himself is why, so far as he goes. What further reasons there may be we can not say. But we may imagine that the why includes other sorts of personalities, and even nature herself, a great, self-revealing person. In the very nature of the case *we* must find the why in personality and in the values which only persons can appreciate. If there be other whys they apparently can not appear to us as men. At least nature's plan includes, comprehends the personal.

Survey the whole sweep of evolution; the wonder of regulation amid the immensities of the universe, beyond the reach of the most powerful telescope; the equal wonder of regulation amid the minutae of atomic structure, far beyond the penetration of the microscope; the emergence of life on the earth, that speck of the universe of which we know most; the gradual development of intelligence, of reason, of appreciation of beauty and of power to create beauty, even the transcendent beauty of personal character. A star is no greater than a violet; gravitation is a force that can not transcend love. But it is all one, beginning in the dust and reaching up into persons who can appreciate and create beauty, a constantly changing whole. And it doth not yet appear what there shall be.

NOVEMBER 10, 1933

[5] "To my thought; my experience and my observation of nature suggest, as the most probable guess I can make, that nature has its origin in intelligence, in love of the beautiful and in purpose, that is, in personality. The evidence for this, as I see it, seems to me to establish a very strong probability that this hypothesis corresponds to reality, and so I live with the thought of its probability steadily in my consciousness. I can not make it seem probable or real to me that nature simply came to be, or always was, as it is, merely by chance or without thought or plan or purpose. And I can not see that the fact that I can not, as yet at least, understand the origin of personality weakens in the least the evidence that personality not my own does exist and is active in the universe. Science does not refuse to form any working hypothesis about its problem in hand, because it can not find an hypothesis that explains everything at once. It simply tackles its problems one by one, tests and modifies and develops them—all with the hope and with the experience that in this way progress may be made toward a larger vision of reality. Of course, if from my experience and observation I draw the induction that personality not my own exists and is active in the universe, and if this induction leads to contradictions or absurdities or increased rather than decreased difficulty in understanding nature, then my guess is worse than useless. But if it leads only to an unsolved mystery beyond, then it does only what all new insights into reality do for us. The larger the circle of our understanding, the wider the circumference at which we touch our unsolved mysteries." (From a letter by my brother, Wilmot V. Metcalf, to one of his pupils.)

WILD LIFE RESEARCH AS A PROFESSION

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THIS article is written for a purpose. The purpose is to further ecological research on wild species, particularly vertebrates, the findings of which research may be of significance in the sane administration of natural resources. It is written for whatever value it may have for young people—let us say, those about to begin college—who want to enter or think they want to enter this field professionally.

I specify prospective college entrants because at this stage many sense the necessity of preparing themselves for a definite lifework, yet have only the haziest ideas as to what they will do for a living. Potentially strong man-power may drift into vocational blind alleys, to remain indefinitely as unproductive and unhappy misfits, often for little reason other than that at the time there seemed no alternative open to them. Of course, misfits can be as unfortunately situated in wild life research as in any other field, or perhaps more so; unless one is reasonably fitted for this sort of thing and wants to get into it chiefly for its own sake, he had best not turn too optimistically toward the field as a profession.

Wild life research is scientific in nature and must be sufficiently well done to hold together when subjected to scientific criticism. It demands mentalities equivalent to those demanded by other sciences. Although relatively mediocre minds may turn out excellent work through sheer effort, there is a limit to what effort alone can accomplish. And the field, though new and undermanned, is not devoid of competition.

Questions as to physique, personality, temperament requirements, etc., draw about the same variable answers that one would predict. The work itself may fall between all possible extremes, governed by what the investigator either wants to do or has to do, or both. The most effective procedure in ecological research seems one of alternate study of a species in a natural environment and under controlled conditions, that is, observation checked by experimentation. Field work frequently entails strenuous physical exertion or even hardship. Laboratory routine, correspondence, technical reading and writing, speaking and advisory duties may all receive a greater or less emphasis.

With respect to the matter of personal attitude, may it be said here that unless one is possessed of an enduring fascination for the out-of-doors, he is not apt to find wild life research much more than only a profession, one among a number for which he may be equally qualified. If this phase of ecology is really his field he should be responsive to the nameless appeal of the raw drama of living creatures as he is to little else; he should know the out-of-doors also as a refuge in which he may seek peace when tired, restless or discouraged. Otherwise, he may never feel that he receives returns commensurate with what he almost certainly will have to pay in one way or another.

Does the prospective worker understand what research is?

Research means the following of the truth, wherever it may lead, regardless of what may be the purpose of the research and the uses to which its findings may be put. If it is not conducted with intellectual honesty it is not research, irrespective of what it may be called. It is impartial and has nothing to prove or to disprove. It recognizes no precedences, no dogmas. It yields to no

authority save superior research. There is nothing mystic or awesome about it; its sole aim is to determine what is so.

Let one therefore make self-inquiry. Can he put aside personal opinions, personal desires, personal expediency, to make analyses on the basis of evidence? Many will be the times when he can expect his pet ideas to be punctured, his carefully thought out generalizations to disintegrate into confusion. He will find out things that do not please him in the least. He may be compelled to do things distasteful, if not revolting to him. Can he do what he has to and more? Can he be his own severest critic? Can he correct his mistakes when they are demonstrated and go on unashamed?

Can he keep his research truths intact in the face of pressure from outside groups with whose individual interests his findings might be at variance, but do so in a way to arouse no unnecessary antagonism? Ideally, research should be exempt from financial pinch, strife, intrigues, prejudices and jealousies, but it rarely is; as a human endeavor it can not be fully exempt from the ills common to human endeavors. A professional research career is not apart from life because it demands a detached perspective. The detached perspective has to be maintained despite the interplay of distractions, worries and crises which most of us have no chance of escaping.

There is something more, something not easy to put in words. Nor am I sure that I know what it is. I think it will be conservative to say that the roots of a real career extend farther back into a man's self than the depths at which he is dominated by such things as economic well-being, pride of achievement, and other more or less material considerations. A man must have more than ability, integrity and ambition. I believe that if he is to attain the heights he must be driven by a veritable passion, not only for his work but for what his work stands for. It must be more than a hobby or a livelihood or a passive pleasure; it must be the supreme interest of his life, for which he is willing to make endless sacrifices.

I may be wrong about this. I do not wish to say that a man with lesser interests could not make good or that his services might not be of great value to conservation. I suppose it is possible for a man to reach the top even though he were not fighting with all he had for something he loved. I suppose it is possible, but I don't see how he could for less incentive put in "that extra" which is so often mistaken for genius.

What should one have to start with before he seriously considers technical training for a profession of wild life research, aside from those qualifications requisite to any research career? What should be his general pre-university background?

Impossible it is, of course, to set up any arbitrary standards by which one's background could in fairness be judged. So much varies with the individual. Nor would it be much more than absurdity to say that research workers in the field of wild life management must arise from a given social stratum or from some other artificially circumscribed group.

An intimate familiarity with the out-of-doors prior to intensive formal training is of incalculable value to one working on ecological problems, though there are people who have demonstrated their ability to handle problems of this kind with scant previous experience. Persons naturally curious about wild creatures and who during youth have engaged in hunting, trapping, field hiking, scout activities and the like have a tremendous initial advantage over those to whom the out-of-doors is bewilderingly new. No one should overrate, however, the value of mere existence in the out-of-doors, for many may spend their entire lives in areas rich in woods and waters without

learning very much about even simple biological relationships.

Extremely profitable may be farm or biological experience and wide contacts with out-doors men of consequence—reliable "old timers," plant and animal ecologists and systematists, ornithologists, museum collectors, geologists, etc. The more diverse the view-points with which one comes in touch the better, provided that one guards against forming opinions too hard-set to yield to contrary factual evidence.

Relative to formal education, I am assuming that the prospective worker is ready to enroll at a college or university of good standing, and which makes available a regular four-year course in science leading to a Bachelor's degree. I am assuming that he has had in high school the usual prescribed English, history, algebra, geometry, physics, biology, as well as civics, sociology, and other orientation courses. A good reading knowledge of French or German acquired from high-school foreign language electives may be very convenient later on.

As a college underclassman, the student will probably be well occupied with prescribed work, regardless of the field of natural science in which he majors. For his freshman and sophomore years it should make comparatively little difference what he takes in classes as long as he keeps to almost any program outlined at competent institutions. These ordinarily include general botany and general zoology, inorganic chemistry, physics, mathematics, economics, history, foreign language, rhetoric and English composition.

The student should not be overanxious to get started on courses in his field of special interest. The first two years of college is no time to specialize; they should be spent in laying a sound groundwork for future study. In addition to the basic sciences, courses in English are of distinct value. The fact might as well be recognized that a scientific worker *must* be able to write and speak well if his endeavors are to count for the most. Though he may detest doing it, if he is wise he will not spare himself in perfecting his English, in school and out.

Underclassmen should try to take the various required courses in the order that the faculty advisers suggest. If one attempts to do about as he pleases, he may get himself entangled in all sorts of scholastic grief. If he postpones much required work, aside from being handicapped throughout his undergraduate study by a lack of fundamental subject-matter he should have had, he will find his schedule in an awkward state of unbalance and he may even be compelled to carry extra courses or attend an extra term or two before he can graduate. Only if financial or other exigencies necessitate irregular attendance may a student as a rule profitably depart from the regular academic procedure.

It should by no means be surmised that routine adherence to a prescribed series of courses will fit one for a career. Broadly, one gets out of college about what one puts into it, however stale may be this platitude. The well known collegiate philosophy of "get by" may enable one to pass the minimum requirements for a degree with a minimum of effort, but what of it? Bachelor's degrees are not so rare any more that they alone assure one of any sort of job, to say nothing of special opportunity.

Some remarks on scholastic standing: Grades may be imperfect criteria of what a student actually knows, but they constitute about the only concrete record of his efficiency. That instructors are sometimes unappreciative or even unfair, that students not infrequently obtain better grades than they deserve by cheating or through tactics such as "handshaking," is not to be denied. Ob-

viously, it is not the simplest thing for students working their way largely or in part through college to make the highest of averages; illness, fatigue and unavoidable distractions may also complicate matters. In the main, though, consistently high or consistently low scholarship speaks quite authoritatively and carries no trivial weight when, for example, applications for fellowships are being considered. Moreover, low scholarship may mean refusal of admission to graduate schools.

All in all, what a student gets out of school is essentially up to him; he can find about what he looks for, the fine and the dross. If a certain course falls below his expectations he should have sufficient mental balance to make the best of it, regardless. The mere fact that he may consider a certain professor's lectures empty should not prevent him from digging what substantial material he can out of the text-books.

For junior and senior years, heavier biological courses may be recommended. Vertebrate and invertebrate zoology, adequate plant morphology and taxonomy, genetics, courses in field zoology and field botany should be highly desirable. Courses in science other than biological should include organic and physiological chemistry, geology (preferably with some reference to soils), and probably meteorology, and theory of statistics or biometry.

The question might arise as to the advisability of taking courses outside of the scientific field in which one intends to specialize. In answer to this it may be pointed out that no real ecological problem can be confined within the narrow limits of a specific field; it will have ramifications extending in every direction. One may not necessarily be expected to conduct research in all related fields, but it will behoove him to be able to make intelligent inquiry of other specialists when confronted by novel developments or technical obstacles. Nor is an investigator's scientific rating raised if he can not see far enough out of his professed subject to avoid basic blunders of a kind surprising from college-trained men.

English and public speaking should be continued; similarly, foreign languages (German, if French was taken in high school, or *vice versa*). If the student plans to go on for graduate work—which he almost has to do if he hopes to make the most of his possibilities in research—he can well remind himself that a reading knowledge of either French or German is required for a Master's degree; both, for the Ph.D. These are not empty requirements—he will find use for the languages.

Extra-curricular pursuits need to be accorded the proper emphasis. Summer employment, where one has any choice, should be of such nature as to provide more than financial assistance. Temporary jobs at biological stations, museums, and camp and outdoor work of many kinds may offer invaluable experience. Often is it judicious to take a comparatively low paying job that has unusually advantageous features otherwise. In case the student is young and has an opportunity to accompany a scientific expedition, for instance, the interruption of formal schooling for a year or so might not be unthinkable.

And it will be no handicap to one's future career if he learns to fit painlessly into social activities, if he can converse intelligently on a diversity of topics ranging from sports to arts. Again, this calls for balance, lest he gravitate into extremes not in keeping with his permanent welfare.

Let us discuss graduate training.

While small or medium-sized institutions may be entirely suitable for undergraduate studies, it is generally more satisfactory to take advanced degrees at big schools having superior personnel

and equipment. Certain departments in certain schools may have international reputations for their strength in particular fields. This article can not make specific recommendations other than to advise the student to select his school on the basis of what he wants and can get. He should understand, too, that graduate work may mean a far faster pace with more exacting demands than anything he had even imagined previously. In many graduate departments, grades below the equivalent of "B" rate as failures.

A prospective graduate student should strive to secure a fellowship or an assistantship in the department in which he intends to carry on his major course work. An arrangement of this sort, besides furnishing a small stipend, may allow him fee exemptions and other privileges, give him greater opportunities for contacts with authorities in the field, and permit him actually to live in a biological atmosphere. The assistantship appointee will, nevertheless, find his progress toward a degree slowed down by regulations and by the pressure of his duties; ordinarily he will have to plan on a year and a half to two years to complete a one-year full time graduate schedule.

Among the courses appropriate for the first year of graduate study might be listed parasitology, human physiology, psychology, animal ecology, organic evolution, entomology, ornithology, mammalogy, and vertebrate embryology. This is about the time, also, when most students get their first real taste of research although they may have worked on minor problems earlier in their academic career. Problems having to do with wild vertebrates, and which, if desired, could be amplified into doctorate research, should be sought.

The department or the institution may or may not require a Master's thesis. Similarly, contingent upon the policy of the school and the suggestions of faculty advisers, it may be optional with the student to take his Master's examination and degree, or to omit the Master's and go on directly for the Ph.D. Commonly the Master's is taken.

One contemplating doctorate study should take inventory of himself, weigh candidly the question of his ability to make the grade. He should talk this matter over with his advisers, who ought to know something of his capabilities after a year of graduate class work. He should decide whether he is willing to pay the price.

The minimum price is two more years' grind after the Master's or equivalent, often of an intensity inconceivable to those who have not gone through it. Doubtless to persons of natural brilliance or exceptional background the achievement of the doctorate may be in no way an ordeal, but the chances are that practically any one of good mental equipment who finishes in two years will have to travel at top speed, and considerably faster than he ever thought he could.

Granted that the student expects to continue, he should at an early date get exact information as to what courses he has to take for a major in Zoology and a minor in Botany. The course work prescribed for doctorate study is not necessarily to be thought of in terms of credits; it varies with the student's academic status and evident needs and is prescribed to give a well rounded foundation for major and minor fields. There may be assigned heavy outside reading entirely apart from course work.

Although the student will register largely for the courses his faculty committee thinks he ought to, he may wish to take others having a particular bearing on his planned life-work. Histology, bacteriology, more chemistry, physics, or mathematics, courses in techniques—these and others may be worth consider-

ing. It stands without saying that one should investigate the content of a given elective before choosing it too readily on the attractiveness of its title.

Most of the Ph.D. course work is culminated about the time of the preliminary examination. This is the one that counts. It is taken when the faculty decides that the student is ready, no earlier than toward the end of the second graduate year. There is hardly any limit to the amount of useful reviewing that could be done in preparation for the preliminary examination, as long as one safeguards physical and mental health. The preliminary examination passed, the Ph.D. candidate devotes most of his time to research and the writing of his thesis. He may take another course or two if he desires or if his advisers decide for him, and he will probably attend seminars in his major and minor subjects. In about a year after his preliminary examination he may hand in his thesis, take his final examination, and, if satisfactory, receive at commencement the degree of Doctor of Philosophy.

After the Ph.D., then what? Perhaps there will be a job. Perhaps the job will be exactly what is wanted; perhaps it will not. Perhaps there will be no job at all. Let no one be deluded into believing that with the acquisition of the degree one acquires relief from such little cares as making a living, getting along with people, and so on; or that the degree will be held as an object of obeisance by the populace at large. Indeed, post-commencement experience might be quite the opposite. With respect to this matter, too, there is need for balance.

One could well get straight in mind what a Ph.D. in biological sciences does and does not stand for. It is intended to signify, in short, that its possessor has a general knowledge of biology and an intimate knowledge of some special field, that he is capable of doing independent research. It is intended to signify that he is academically trained. Informally, some may express the meaning of the doctorate in words to the effect that its recipient has proven his capacity to take punishment in a more or less creditable manner. Whether one allows himself to become broadened or narrowed, tempered or warped, depends more upon the individual than upon the academic routine.

The Ph.D. does not assure one of infallibility in judgment nor of inexhaustible funds of information nor of supreme material advantages. It does not assure one of the "inside track" in competitive relations with one's fellow men. It does not assure one of happiness nor of any of the tangible and intangible objectives toward which we strive. It does not assure one of anything; it does not guarantee anything. It is but the certificate of a formal education.

Suppose that one had invested weary years in preparation for a career of wild life research and had sacrificed and fought and gambled for the fulfilment of his ambition, what would be his prospects of finding a position into which he could fit, with opportunities to do interesting and productive work and to make a comfortable livelihood? I don't know. There may be openings on the staffs of universities or agricultural colleges, federal or state biological surveys, national or state parks, fish and game departments, or other public or private organizations as endowed foundations, sportsment's associations, large hunting clubs, estates and conservation societies. There may not be. I know of no profession where one may feel free from uncertainty, but that of wild life research is, at any rate, far from being overcrowded at present, regardless of what it may become in the future.

Why isn't it overcrowded, when in America alone hundreds of careers have been devoted to the natural history of

hundreds of vertebrate species which we designate as "wild life"?

The earlier work dealt almost entirely with the classification of these species and the determination of their evolutionary affinities. Subsequent work dealt with the economics of wild life. Now, the time is ripe to study wild species from the standpoint of their environment, so that they, and thus their inherent values, can be intelligently conserved.

Deliberate control of wild life environment for conservation purposes had hardly begun a decade ago. The ecology of very few species has been worked out with any semblance of thoroughness. Every field, every woodlet, every hedgerow, every marsh presents problems unfathomed by human minds but vital to a harmonious integration of civilization and nature, problems innumerable and scarcely touched. Fluctuations in plant and animal populations, predator and prey relationships, direct and indirect competition of native and exotic species, life histories, environmental factors influencing reproduction and fitness, physiology and behavior—here we have realms of unknowns, plenty to do and an urgent demand that it be done, particularly on game birds and mammals, fur-bearers, and other economically important forms. Some work of this sort is under way in various sections of the country and more is scheduled, but, as could be expected, many worthy programs have been severely cramped, if not shelved, on account of the current financial difficulties.

No one can foresee precisely where events and the dominant social trends will take us. Admitted that we do not know for sure whether the years will find wild life research on the ascendency or on the wane, the training for this special field is not so specialized as to incapacitate one for work in other biological fields, should such be desirable or imperative. Few are the courses suggested which would not be of value to persons engaged in nearly any biological teaching or research. Even were one ultimately to take up a profession remote from academic or economic biology, still the biological training should be anything but a dead loss. As living creatures, we can not divorce ourselves from life and life's principles, whatever we do. As living creatures, ourselves profoundly affected by ecological dynamics, a knowledge of salient ecological phenomena conceivably would not be to our disadvantage, however glaringly our lives deviated from careers originally planned.

SCIENCE IN CHAUCER

By PERCY A. HOUSEMAN

HADDONFIELD, N. J.

In the January, 1932, issue of this journal, Professor D. F. Fraser-Harris has paid eloquent tribute to the remarkable breadth of scientific information and the penetrating powers of observation which Shakespeare possessed. Professor Fraser-Harris has made a valuable contribution toward bridging the gap which all too frequently separates different branches of human activity and interest. We are gradually coming to realize that our work, play, love and worship need not and should not be kept in separate pigeonholes. Science should recognize its debt to literature as freely as literature should welcome the companionship of science. With this thought in mind, it seemed of interest to point out the wealth of scientific knowledge displayed by Geoffrey Chaucer, that genius of English literature who lived two hundred years before Shakespeare.

It is a matter of surprise and regret that Chaucer is so generally neglected by the reading public. To be sure, the difficulty with the spelling, pronunciation and vocabulary of Middle English is something of a deterrent, but this obstacle quickly vanishes as familiarity is acquired, and is actually transformed to a feature of attraction. It must further be admitted that some of Chaucer's themes are unseemly, judged by the standards of good taste of today; but it must be remembered that there are many unseemly people in the world, as Shakespeare knew only too well, and unseemliness can not be ignored if literature is to portray life clearly and as a whole. In Chaucer's defense, if indeed defense be needed, it may be pointed out that his occasional Rabelaisian robustness is properly balanced by the truly religious spirit in which he often writes, and by the catholicity of his vision. In his love of everything in the world—the rocks, the trees, the birds, the sunrise and the common man—he stands second to none. As far as science is concerned, it is a question whether in knowledge and penetration he does not actually surpass Shakespeare. Remembering that Chaucer lived in the second half of the fourteenth century, his acumen in science is amazing. There is hardly a branch of it in which he does not evince both interest and insight, so that the commentator is confronted with an embarrassment of riches.

Starting with what may be called kitchen-chemistry, we note that Chaucer has a weakness for spices and herbs. Frequent reference is made to clove, cinnamon, anise, caraway, ginger,

> And many a spice delitable
> To eten whan men rise fro table.

He must have been particularly fond of licorice, references to which are scattered through his works. The "pore scoler" of the Miller's Tale is described as being "himself so swete as is the roote of licorys." Another character, Absolon, in the same story "cheweth lycoris to smellen swete,"—a clear recognition by Chaucer of the digestive properties of what we now know as enzymes. Still another member of the distinguished family of Canterbury Tales is Sir Thopas, who describes his passage through a forest in which "ther springen herbes greet and small," and among them the licorice plant. When Sir Thopas returns home, he calls to-

gether his "mynstrales and gestours," who regale him with "wyn, gyngebred, licorys" and other delicacies. Another favorite drug of Chaucer is valerian, which in Middle English is called "cetewale," and which appears to have been used both as a sedative and as an ingredient of perfumes.

In the field of metallurgical-chemistry Chaucer has a remarkable fund of information. His writings are rich in the fantastic lore of alchemy, but Chaucer is fully aware of the roguery which was so frequently practised by unscrupulous alchemists to dupe the unwary with claims for the transmutation of base metals into gold and silver. Vain efforts "of a single pound to make tweye" form the plot of the fascinating "Canon's Yeoman's Tale." The Yeoman, whose office was to "blowe the fyr," bemoans the repeated failures:

Yet is it fals; and ay we have good hope
It for to do, and after it we grope.
But that science is so far us before,
We never can, although we had it swore. . . .
That slippery science hath me made so bare,
That I have no good, wher that ever I fare.

Then follows a long list of substances and of apparatus used in the preparation of the "yngottes"; orpiment, litharge, sal armoniak, verdegres, boras, arsenek, brimstoon, unslekked lym, glayre of an ey (white of an egg), alym, resalgar, and many others, treated in alembikes, concurbites (distilling flasks), viols, sublimatories, croslets (crucibles) and descensories (percolators?); a list which would have formed a goodly contribution to a chemical dictionary of that day. The woeful outcome of the experiment will strike a sympathetic note in the heart of many a modern chemist:

And wit ye how? ful ofte it happeth so,
The pot to-breketh, and farwel, al is go.

Later comes the climax of the tale, with the rascally Canon slipping an ounce of silver into the assay in order that it may be found at the end.

Just as Chaucer's chemistry contains much alchemy, so his astronomy is naturally admixed with a good deal of astrology. He planned an elaborate work called "A Treatise on the Astrolabe," but like many of his undertakings, it was never finished, less than two of the contemplated five parts being completed. The "Treatise," in so far as it was written, consists of a elaborate description of a very intricate instrument and of its astronomical uses. On the Astrolabe were marked the signs of the zodiac together with all kinds of points, lines and angles. It was used to compute the altitude of heavenly bodies, longitude and latitude, the points of the compass, etc., by means of shadows, angles, and what Chaucer quaintly calls "pin-prikkes." That Chaucer's ten-year-old son, for whose edification the work was intended, could ever have comprehended a single word of it, is past belief.

Chaucer makes frequent reference to the determination of the date and the time of day from the position of the sun. So for example in the words of "Oure Hoste" to the Canterbury pilgrims:

Oure Hoste saw that in heven the brighte sonne
The ark of his artificial day had ronne
The fourthe part and half an hour or more;
And though he were not depe expert in lore,
He wist it was the eightetenthe day
Of April that is messanger to May;
And saw wel that the shade of every tree
Was in the lengthe the same quantitee
That was the body erecte, that caused it;
And therfore by the shadwe he took his wit,
That Phebus, which that shoon so fair and brighte
Degrees was five and fourty clombe on highte;
And for that day, as in that latitude,
It was ten of the clokke, he gan conclude;

Of medicine Chaucer writes relatively little, though one of his pilgrims is a "Doctour of Physik" who was "a very parfit practisour" and whose partnership with the pharmacist is described in satirical vein:

Ful redy hadde he his apothecaries,
To send him drugges and electuaries,
For eche of them made the other for to wynne;
Their frendshipe was not newe to beginne.

Chaucer is well aware of the limitations of drugs when he says of Arcyte in the Knightes Tale:

And certeynly where nature will not wirche
Farwel physik; go bere the man to chirche.

Then follows a vivid picture of the symptoms of death:

Swelleth the brest of Arcyte, and the sore
Encreaseth at his herte more and more . . .
For from his herte up to his brest was come
The cold of deth, that him had overcome.
And yet moreover in his armes two
The vital strength is lost, and all i-go.
At last the intellect, withouten more
That dwelled in his herte sik and sore
Gan fayle, when the herte felte death,
Dusked his eyen two and fayled his breth. . . .
His spiryt chaunged was and wente there
As I cam never, I cannot tellen where.

Elaborate preparations are made for the cremation of Arcyte's body. Here is a list of twenty trees which are made to contribute to the funeral pyre:

Ook, fir, birch, asp, aldir, holm, popler, wylugh, elm, plane, assh, box, chestnut, laurer, mapul, thorn, beech, hasel, ew, whippeltree (cornel).

No less keen than his interest in trees is Chaucer's delight in birds and flowers. Thirty-four different kinds of birds are enumerated in the assembly for his "Parlement of Foules," and many times throughout his poems he rhapsodises on the "briddes" and "floures":

Herken these blisful briddes how they sing
And see the freshe floures how they spring
Ful is mine heart of revel and solas.

It is when thus inspired by natural science that he exclaims:

Farwel my book and my devocioun.

The glory of the sunrise and sunset moves him deeply, yet in his poetic admiration he does not forget to record the physics of the ruddy dawn:

The vapour which that up the erthe shedde
Maketh the sonne seme brood and red.

It would be difficult to produce a more concise statement of the screening effect caused by the long layer of air through which the sun's rays must pass at sunrise and sunset.

From the point of view of scientific interest, perhaps the most brilliant and ingenious work of Chaucer is his "Hous of Fame." Here he boldly invades the realm of physics and invents a Theory of Sound. The plot of "The Hous of Fame" centers upon an aerial cruise which Chaucer takes while clutched in the talons of a golden eagle. When far above the earth, the eagle, being in a position to state its views without fear of contradiction, proceeds to lecture Chaucer on sundry scientific and philosophical subjects. At the end of a one-sided dissertation on the cause of sound, the eagle asks Chaucer if he does not agree that its theory of sound stands proven. Chaucer, diplomatic as well as sagacious, thinks of the talons from which he hangs so dizzily suspended and with delicious humor limits his reply to the single word "Yis." The eagle's theory of sound is derived from the general idea advanced by Aristotle that everything has a natural environment or home at which it seeks to arrive. The natural home of the river is the sea, of heavy things "downward," and of light things "on highte."

Sound is nought but air y-broken,
And every speche that is spoken,
Lowde or pryvee, foul or fair,
In his substance is but air;
For as flame is but lighted smoke
Right so sound is air y-broke. . . .

The air is twyst with violence,
And rent: lo, this is my sentence.

Sound is conceived as breaking through the lower air and rising in ever-widening concentric circles to the upper levels, much as a stone cast into water causes circular waves to spread out. All sound

thus arrives at last at the "Hous of Fame," where it resounds like the

> Betying of the see against the roches holowe
> Whan tempest doth the shippes swalowe.

The height of scientific fantasy is reached by every speech assuming the likeness of the speaker, so giving the listener the ability to pass backward through time, and hear the words as they issue from the speaker's lips.

In his article on biology in Shakespeare, Professor Fraser-Harris devotes a good deal of attention to Shakespeare's views on sleep. It may be fitting to conclude this essay with a consideration of Chaucer's reference to sleep, and more particularly to dreams and visions. Shakespeare's reference in Macbeth (ii, 2) to sleep as a nourisher is anticipated by Chaucer in "The Squire's Tale" where he speaks of

> The norice of digestion, the sleep.

Of the ravages caused by insomnia he says in "The Death of Blanche the Duchesse":

> I have gret wonder by this lighte
> How that I live, for day nor nighte
> I may slepe wel nigh nought; . . .
> For Nature woulde not suffise
> To none earthly creature
> Not long time to endure
> Withoute slepe.

Dreams and visions (swevenes) play an important rôle in Chaucer's work, and the use of this device was quite fashionable in the Middle Ages. An outstanding example is the French poem "Roman de la Rose," of unknown authorship, which was translated by Chaucer. Chaucer followed this type in his dream poem "The Death of Blanche the Duchesse," and dreams are also prominent in "Troilus and Criseyde," "The Hous of Fame," "The Parlement of Foules," and in the "Nun's Priest's Tale" of Chanticler in the Canterbury Tales. He seems not quite able to make up his mind whether dreams are no more than the result of dining not wisely but too well, or whether they have real meaning. The opposing views are admirably set forth in the delightful tale of Chanticler and Pertelote. The adoring wife Pertelote calls upon Cato to support her view:

> Alas! and can ye be of dremes agast?
> Nothing, God wot, but vanitee at last.
> Dremes are engendred of repletions
> And often of fumes and ill complexiouns
> Whan humours be too abundant in a wight.
> Certes this dreem, which ye have had tonight
> Cometh of the grete superfluitee
> Of your blood and red colour, pardee.

But Chanticler maintains stoutly, and with many references to authorities, that men

> Have wel founden by experience
> That dremes be significaciouns
> As wel of joye, as tribulaciouns. . . .
> And some tyme dremes ben (I say not alle)
> Warnyng of thinges that shall after falle. . . .
> Shortly I say as for conclusioun
> That I shall have of this by visioun
> Adversitee.

That Chanticler does in fact shortly meet with such adversity as almost costs him his life would certainly lend some support to his views! Chaucer is evidently much puzzled by the whole subject and devotes the sixty-five lines of the proem of the first book of "The Hous of Fame" to wondering what is the cause and significance of dreams:

> And why the effect followeth of some,
> And of some it shall never come;
> Why that is an a-vision,
> And this a revelacioun;
> Why this a fantom, why these oracles.
> I know it not.

For those who know Chaucer well and therefore love him, it is hoped that this paper, sketchy though it be, will be of interest in calling attention to the extraordinary depth of his insight into many branches of science. For those who love him less because they know him less, it may serve as an introduction which may ripen into a friendship well worth while.

SCIENCE SERVICE RADIO TALKS

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INSULIN AND DIABETES

By Dr. VINCENT DU VIGNEAUD

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In spite of the fact that diabetes has been known for centuries it was not until twelve years ago that a means of combating this hitherto fatal disease was furnished by the discovery of insulin. As far back as the Egyptian writings of the fifteenth century before Christ, we can find references to a disease which was clearly the diabetes mellitus that we know of to-day. It seems rather incredible, though, that it was not until over three thousand years later in the seventeenth century that the excretion of sugar was first suspected. Willis, a great English physician, was the first to note this. In describing the disease Willis referred to the fact that the diabetic excretion was sweetish like honey. It is from this observation that diabetes mellitus gets its name, for the term mellitus is derived from a Greek word meaning honey. The term diabetes itself simply refers to the abnormally large amount of water excreted. There are in fact a number of kinds of diabetes and one must use the descriptive term diabetes mellitus to refer to the type of diabetes in which sugar is excreted and in which there is also an increased amount of sugar in the blood.

Progress throughout the centuries was indeed very slow in the understanding of this fatal disease, when suddenly there occurred an epoch-making discovery in 1889 in Germany by two workers, Minkowski and von Mering. They found that removal of the pancreas, which is a small glandular structure located just below the stomach, produced a fatal diabetes in dogs, similar in all respects to the diabetes mellitus of man. Further work by these investigators disclosed that these animals from which the pancreas had been removed were unable to oxidize sugar in their bodies; sugar therefore accumulated in the blood and was finally excreted by the kidneys.

Exactly the same situation occurs in human diabetes mellitus. The patient loses the power to burn or utilize sugar in the body and the sugar is likewise lost through the kidneys. From the fact that removal of the pancreas should cause such a condition these early investigators concluded that some substance was produced by the pancreas which enabled the body to utilize sugar and that for some reason the pancreas of a diabetic failed to produce this substance.

Von Mering and Minkowski therefore attempted to prepare extracts of this hypothetical substance from the pancreas to find out whether the administration of the extract to animals that had their pancreases removed would enable them to utilize sugar. Their many attempts ended in failure. Others were attracted by these experiments and throughout the ensuing years many investigators tried to prepare active extracts. Either their attempts were greeted with failure or else the results were inconclusive.

Yet there persisted the staunch belief that there must be present in the pancreatic gland a hormone or active prin-

ciple which regulated sugar oxidation and if extractable would offer means of combating diabetes. It was not, however, until twelve years ago that definite substantiation of this belief was established. This great advance was accomplished by two young Canadians at the University of Toronto, Banting and Best. They were successful in preparing an extract of the pancreas which would lower the blood sugar, bring about oxidation of sugar in the body and what is paramount to all, save the lives of many diabetics.

Although the many investigations of the preparation of active extracts of the pancreas in the years intervening between the work of von Mering and Minkowski and Banting and Best were not successful in establishing unequivocal proof of the existence of insulin, yet very much worthwhile information was gained. Some workers such as Zuelzer, Scott, Murlin and others had without question obtained active extracts and their work contributed much to the fund of knowledge and experience which finally culminated in the dramatic triumph of Banting and Best. It does not detract from the triumph of these latter workers to emphasize the significance of the contributions of those who laid the foundations upon which this brilliant work was built. As many of the earlier workers obtained negative results on making simple extracts of the whole pancreatic glands it began to be suspected that the digestive enzymes of the pancreas, which would be present in the extracts, destroyed the insulin. The pancreas, you see, is also a digestive organ and produces digestive enzymes or catalysts that are poured into the intestinal tract to aid in the breakdown of foodstuffs.

Under the microscope two types of cells can be identified in the pancreas. One type of cell produces an enzyme secretion which is collected by little tubes or tubules which unite to form larger tubules until finally the secretion is emptied into the intestine through one or two large ducts. In the intestine this so-called external secretion aids in the digestion of foodstuffs. The other type of cell occurs in little groups which are called the islets of Langerhans, named after the man who discovered them. Evidence had already accumulated that it was these cells that must be the ones that produced a sugar regulating hormone, if such a compound existed.

If, then, a simple extract with water was made of the whole pancreas, then the digestive enzymes present in these other cells might destroy the active sugar regulating hormone that was present in the islets of Langerhans. But some other workers had already shown that if in an animal the ducts that carry the external secretion into the intestine be tied off, degeneration of the cells that produce the enzymes would take place, but that the islets of Langerhans would remain intact. Such a pancreas would therefore have no digestive enzymes in it but might contain the sugar-regulating hormone. The latter might then be extracted without fear of destruction by the digestive enzymes. This was the basic idea behind Banting's experiment. Banting and Best actually carried out such an experiment and made extracts of pancreases produced in such a way as I have just indicated. They were able to keep a diabetic dog alive by the administration of these extracts. It was this brilliant achievement which finally led to the potent extracts which are used medicinally.

After this successful experiment they then took advantage of an observation that had previously been made, that the islets develop long before the other type of cells in the animal before birth. They therefore extracted the pancreases of unborn animals obtained from the slaughter houses. These extracts were also efficacious. With the experience they now had at their command they

turned to making extracts from normal beef and pork pancreases. They prevented the enzymes of the external secretion from destroying the insulin by extracting the insulin with acid alcohol; this is the basis of the methods now used in preparing insulin solutions for medicinal uses.

But what is it that is present in these extracts that produce such profound physiological effects? These extracts of course contained a host of other compounds besides insulin. Chemists all over the world started on the quest of isolating the active principle itself from these extracts. They wished to isolate it in chemically pure form so that its chemistry could be studied. It proved to be very elusive and it was not until five years later that Prof. John J. Abel of the Johns Hopkins University succeeded in isolating the pure crystalline insulin. The obtaining of insulin in the pure state opened the possibility of really attacking the chemical nature of insulin.

The evidence to date indicates that insulin is a protein-like compound. It is extremely complex, and all the constituents that go to make up the molecule are not yet known. Work is in progress in our own and other laboratories to identify these other constituents. One of the striking facts concerning the chemistry of insulin is the high percentage of sulfur that is present. There is much evidence that the sulfur is intimately connected with the activity of the compound. Further work is being done on this relationship. Another line of attack that is being used at present is an attempt to find out if there is within this larger molecule a nucleus which is responsible for the physiological action. This is an attractive hypothesis but it must be admitted that there is no evidence for this idea as yet. Another approach to the insulin problem is the synthesis of various compounds in the hope of finding one that will replace insulin and which might give some idea as to the groupings responsible for the lowering of blood sugar by insulin. But so far, there has been synthesized no compound that can take the place of insulin.

Probably one of the most important aspects of the insulin studies is the attempt to modify insulin in such a way as to retain its physiological activity but so change it that the enzymes in the intestinal tract will not destroy it. In this way it may be possible to develop a method of giving insulin by mouth and avoid the injection of the insulin under the skin which of course becomes very bothersome to the diabetic. It would be a great boon to the treatment of diabetes if this could be accomplished. Yet I must point out that at present there is no preparation of insulin that can be given by mouth which can be relied on to take the place of the regular insulin which must now be given by injection.

It can readily be appreciated how much remains for future research to accomplish. Not only is there much to be done on the chemistry of the compound but at the present time it is not known just how it works in the body. Understanding this, it is to be hoped that a better understanding of diabetes will be arrived at, and to actually find out what is the cause of this malady which is not known at the present time. If the cause is known then possibly a means of preventing it can be worked out.

In this connection it might be mentioned that some very recent work is beginning to throw new light on the diabetic question. It has been found recently that if the pituitary gland, which is a small gland located at the base of the brain, is first removed from an animal and then the pancreas removed, strangely enough, no diabetes occurs. Furthermore extracts of the anterior part of the pituitary gland can cause a diabetic-like condition in the normal animal. This shows that there

is a very intimate relationship between the pituitary and the pancreas, and it is very suggestive that at least in some cases of diabetes an overactivity of the pituitary gland rather than lack of insulin may be responsible for the condition. We can confidently look forward to new work within the coming years from many laboratories throughout the world that will add much to our knowledge concerning this important question. It is entirely possible that our views concerning diabetes and utilization of sugar may be radically changed by this new work.

The entire story of insulin and diabetes emphasizes even more strongly the underlying basis that chemistry affords in the study of modern medicine and further the value of the experimental approach to these complicated clinical questions.

MATHEMATICS IN A CHANGING WORLD

By Dr. ARNOLD DRESDEN

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For the majority of my invisible audience, the word mathematics will conjure up memories of youthful experiences, tearful for some, perhaps aglow with the sense of achievement for others; memories of multiplication tables, of percentage calculations and of similar amusements. All these things are as fixed as the laws of the Medes and Persians, unchangeable as the succession of the seasons, rigid and void of imagination. Whence, then, does this subject derive its importance for the modern rapidly changing world in which every day brings its new problems and its new fashions? To appreciate the importance of mathematics for the maintenance of human existence in such a world we must go beyond the superficial aspects of its elements as taught in the schools and attempt to gain some insight into its fundamental characteristics.

Let us begin by taking a somewhat closer look at the nature of the forces acting on our environment. It is granted by every one that they are complicated in character, that they do not always bring us forward, that frequently we stand still, that many times we retrograde. The situation bears a certain resemblance to that of the motion of the celestial bodies in the days before Copernicus, Kepler and Newton. The motion of the planets was studied from the terrestrial point of view and elaborate systems of epicycles were necessary to introduce some order into their lawless behavior. But when the problem was considered from the point of view of the sun as a central body, a great simplification was effected. The seemingly erratic character of the planetary motion was explained on the basis of a simple hypothesis, that of universal gravitation. To-day we understand that the irregular way in which the planets appear to move arises from the simultaneous operation of a number of motions, each simple and each capable of quite elementary explanation. This suggests a possible direction in which progress may be made in the understanding of our human problems. They have been studied preponderantly from national and even sectional points of view. Now it is one of the fundamental tenets of mathematics that the relations which it studies are never completely understood until they have been considered from the point of view of each of the elements which enter into them. This is pregnantly expressed in a saying of the famous German mathematician Jacobi: "Man muss immer umkehren" (we must always turn things

about). This principle would lead to a thoroughgoing reexamination of the baffling problems which confront us. Is it not possible that they will prove more amenable to explanation if looked at from a world point of view? May it not then turn out that the apparently capricious way in which our world behaves will prove to be due to the simultaneous operation of a number of independent forces, each pulling or pushing in its own way, but each capable of exact understanding? If this should be the case, an analysis of the complex results into their simpler constituents would evidently be of capital importance. Mathematics possesses many methods for such analysis; the interested listener will find examples in the literature of our subject.

Moreover, it is not unlikely that some of the simpler elements whose combination produces our complexities are periodic in character. That is to say, that they pass through a cycle, repeating over and over again a definite sequence of stages. It is well known that several attempts have been made to discover such periodicities in our economic life. The wise words attributed to King Solomon that "there is nothing new under the sun" may be interpreted to mean that periodic laws control all our experience. Mathematics embraces elaborate theories concerning periodic phenomena.

We must look at another aspect of our question. As a science advances, be it a natural or a social science, we secure not only more and more complete data concerning the things that science studies, but we discover that relations exist between various phenomena which at first had been thought of as unconnected. A striking example is Benjamin Franklin's discovery of the identity of lightning with an electric discharge. Modern times have brought recognition of the fact that the productivity per hour of a factory worker is in some way dependent on the length of the working day and on the physical conditions under which his work is performed. We have also learned that the yield of wheat per acre depends upon the nitrogen content of the soil, that the power of resistance to disease of the human body is related to the age of the body as well as to the corpuscular content of its blood, that the index prices of commodities depend upon the amount of free gold, and so forth through a long list of subjects and a wide range of fields. But our knowledge of these dependencies is far from complete. We may know that two things are related, but not what the relation is, nor what conclusions are to be drawn from their relatedness, what predictions it justifies. When two changing magnitudes are so related to each other that to a given amount of one of them, there corresponds a definite amount of the other, we say, in technical language, that they are functionally related, that one is a function of the other. Thus we would say that the productivity per hour is a function of the length of the working day, that the length of a metal bar is a function of its temperature, that the wheat yield per acre is a function of the nitrogen content of the soil, and so on.

A large part of mathematics consists of the study of functional relations, of determining that one which comes nearest to expressing the connection between two accurately measured varying magnitudes, of deducing the properties of such functional relations, of deriving the consequences of their existences. We learn, for instance, that the increase of a certain cause may sometimes carry with it an increase of effect, but at other times a diminution. If we toss a ball into the air the height to which it rises increases with the speed with which the ball is propelled upwards. But if one teaspoonful per day of medicine cures an illness in 10 days, it does not follow that ten times that amount will bring relief in one day, unless it be relief by extinction. Does it need further argument to convince us of the importance for the

understanding of our environment of the study of functional relations?

In his dealings with such relations between variables, the mathematician is not concerned with any concrete interpretation of these variables, but merely with the form of the relation connecting them. The physicist may have found that the pressure and volume of a gas under constant temperature are so related that the product of the numbers measuring these magnitudes is constant. The economist may have learned that the number of producing units and the amount produced by each unit are variables so related that the product of the numbers measuring them is constant. For the mathematician these two observations are but two instances of a functional relation between two variables whose product is constant. He will study this functional relation so as to obtain all its possible consequences and then turn his results back to the physicist and the economist so that they may interpret them each in his own field. Mathematics is therefore an abstract science, interested not in particular, concrete, instances, but in those elements and qualities which are common to a large variety of concrete cases. A mathematical formula holds within its abstract form an endless mass of isolated conclusions. This character of the subject is evident even in its elements. When a child learns that 4 plus 5 equals 9, it has within its grasp numberless special cases, *e.g.*, that 4 apples added to 5 apples makes 9 apples, that 4 books added to 5 books makes 9 books, and so forth. It is its abstract character which gives mathematics its great power of adaptation to the problems and requirements of an ever-expanding world.

Finally I must call brief attention to the division of mathematics which is known as the theory of transformations. When you move objects about on a table, when you toss a ball up into the air, when you send out sound waves from your vocal chords, when an acorn grows into an oak tree, when the image of an object is formed on the retina, transformations take place. Mathematicians have realized the importance of the nature of a transformation and have classified them according to their characteristic properties, rather than with respect to the objects on which they operate; they have inquired, for each type of transformation, whether anything remained unchanged when such transformations are carried out—in technical language, they have looked for invariants. It should be expected that the determination of the invariants of a system reveals its fundamental properties. When objects are moved about in space, their shape and weight are presumably invariant. The only properties of an object which sight can reveal are those which are invariant under the transformation from object to retinal image. Many of the problems which a changing world puts before us can be summed up in terms of the theory of transformation. To find out the properties of the transformation, to discover what remains invariant under them, these are fundamental problems of which even a partial solution only would be of great value.

These four aspects of the science of mathematics, its powers of analysis, its concern with functional relations, its abstract nature and its interest in invariants under transformations are the ones to which I want to direct your attention in this brief presentation of the significance of mathematics in a changing world. They are all abstract in character; mathematicians cultivate them for their inherent interest. They have been turned to fruitful account probably because they reveal fundamental qualities of the human mind; but these applications belong to the sciences, natural and social.

WHAT X-RAYS CAN TELL US ABOUT ATOMS

By Dr. SAMUEL K. ALLISON
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X-RAYS were discovered in 1895 by the German physicist, Wilhelm Röntgen, then working at the University of Würzburg. The importance of the discovery to the medical profession was at once recognized. In a few weeks after Röntgen's announcement the new rays had been used in the diagnosis of bone fractures and in the location of foreign bodies in wounds. To-day it is difficult to imagine surgery and dentistry being practised without the use of the information readily obtained from x-rays.

It is not of these applications to the medical profession, which are familiar to every one, that I wish to speak in this brief talk. I shall, however, try to give some idea of the use of x-rays as a tool in the investigation of the fundamental problems confronting the physicist and the chemist in their studies of the ultimate nature of matter. It is probably not popularly realized that the advances in the sister sciences, physics and chemistry, achieved by the use of x-rays have been fully as great as the resultant improvements in medical and surgical practise.

I shall try to give a brief explanation of the extraordinary importance of x-rays as a scientific tool. In our studies of the structure of matter, we are interested in atoms, and in the electrons which make up atoms. Atoms are extremely minute things, and we know definitely that they are so small as to be forever beyond the possibility of direct vision, even when aided by the most powerful microscope. This statement is not a criticism of the skill of the instrument makers who construct microscopes; the fundamental reason for the invisibility of atoms lies much deeper than a question of instrument design. It lies in the fact that we see by means of light waves, and the light waves to which our eyes respond with the sensation of sight have wave-lengths a thousand times greater than the diameters of the atoms which we wish to see.

I shall attempt to illustrate the difficulty by means of an analogy. Let us imagine a town on the seacoast with a not too well-protected harbor into which ocean swells are advancing on a calm day. As the waves strike piers, wharves or ships at anchor, reflected waves will be set up which interfere with the advancing waves and with each other, so that the surface of the water near these large bodies is crisscrossed by smaller waves and has especially high humps of water where two wave-crests overlap, and especially deep troughs where one wave-trough coincides with another. The pattern produced on the water in such a case is called a diffraction pattern. Now it is conceivable that a physicist, seeking to enter the harbor in a fog which cut off vision of the shore, could locate the position of large objects by observing the diffraction pattern and thus studying the waves reflected from them. I must here remark, however, that in any actual case the services of a certified pilot would be infinitely preferable, because while the physicist was making the elaborate calculations necessary, the ship he was steering would be likely to crash into the object he wished to avoid.

The point of the illustration is that, although the problem of locating large-sized objects in the harbor by means of the reflected waves is not insoluble, it would be quite impossible to locate the barnacles on a ship or the grains of sand on a beach by such a study. The wave-length, or crest-to-crest distance of the advancing waves, is far too large to reveal such minute details. In an analo-

gous way an attempt to study the positions of atoms in solids, or the shapes of atoms, by means of visible light is bound to fail, due to the great disparity in the wave-length of the light and the dimensions of the atoms. Here is where the x-rays come to our aid. They are similar in nature to light waves, but their wave-length is a thousand times shorter. In studying the diffraction patterns produced when x-ray waves impinge on matter, the physicist has ample time to make his calculations, since, in contrast to the situation in the preceding fanciful illustration, his life is not in danger, and he can actually locate the positions of the atoms, each of which reflects, or in a more technical language, scatters secondary x-ray waves.

As a result of this success, the advent of x-rays eventually caused an upheaval in the venerable science of crystallography. It is unfortunate that the nontechnical person has little or no contact with crystals in the sense that the scientist understands the word. In popular speech the word crystal suggests something transparent, especially a transparent jewel, but in its technical sense transparency is not at all an essential attribute of a crystal. To the scientist a large crystal is a solid which has been formed in such a way that it can exhibit its natural shape, which for all substances is one bounded by flat surfaces and edges. The materials with which we come in contact in everyday life, with the exception of glass, can usually be shown under the microscope to be agglomerations of enormous numbers of minute crystals, wedged together. Snowflakes, if examined closely, exhibit the most beautiful regular patterns and are bounded by planes and edges, constituting examples of crystals.

Crystallography is the study of these objects and, due to their great regularity of shape, scientists have long suspected that the atoms of which they are made are not arranged in haphazard fashion, but on the contrary are placed in some very regular array. By the study of the diffraction patterns produced when x-rays strike crystals, the expectations of the crystallographers have been confirmed, and what was previously a guess has been reduced to tabulated numerical values of interatomic distances and designs. Thus the positions of atoms in crystals of ordinary table salt is known with great precision. Chemists have long known that table salt contains only two kinds of atoms, those of the elements sodium and chlorine. From the use of x-rays we know that these are arranged in rows and columns throughout space in such a way that in the three principal directions sodium and chlorine atoms alternate.

This is a very simple type of crystal, and others, much more complicated, have been unraveled. As the work goes on, scientists are learning more and more about the problem of chemical combination; the relative positions of atoms in solids giving important clues as to the nature of the chemical forces which hold them together.

X-rays can be produced whose wavelength is short enough for the study of the positions of electrons inside atoms. Each electron scatters a wave which interferes with waves scattered by other electrons in the same atom, producing a diffraction pattern the study of which will reveal the electronic structure of the atom.

I shall now mention quite a different way in which we can get information about atoms from x-rays. In the present case, the study of the beam coming from an x-ray tube tells us something about the atoms in the target of the tube. In the production of x-rays, high speed electrons strike against a metal block in the tube called the target. Professor A. H. Compton has given us the following instructive analogy. He compares the process to the impact of machine gun

bullets on a steel wall. The impacting bullets are the electrons, and the noise produced by the impacts corresponds to the x-rays. It is true that most of the x-rays produced in a tube have this noise-like or irregular character, but a careful analysis of the radiation discloses that amid the irregularity there stand out a few simple waves. It is as if the bullets in a few cases penetrated the steel wall and struck a musical gong or bell, causing it to emit a pure tone, which is almost but not quite drowned out by the general din. These the physicist describes as characteristic wave-lengths, superimposed on the general background.

It is found that these characteristic wave-lengths depend on the kind of atom of which the target is built; copper, iron, aluminum, and so forth, having different and typical wave-lengths. These arise from vibrations of the electrons deeply embedded in the atomic structure, and from the wave-length we deduce the forces with which these electrons are bound.

When these characteristic wave-lengths have been determined for a large number of different elements, we find that the elements, arranged in the order of their wave-lengths, fall into the same order as they do when they are listed according to their atomic weights. This regularity convinces us that the electronic structure of atoms is not built in a random manner, but proceeds according to a definite and inflexible plan, at least as far as the inner regions are concerned.

These inner regions in atoms like those of gold and lead we find to be exactly alike, the only difference being that, in the case of lead, the inner electrons are somewhat more tightly bound than are those of gold. How then shall we account for the obvious differences in properties between the two substances; the yellowness of gold and the grayness of lead, the melting of lead at a much lower temperature than gold, and so on?

These properties we ascribe to the arrangement of the very outermost electrons in the atom, which do not give us information as to their positions through the medium of x-rays. It is these superficial electrons which control the properties of matter, with the exception of weight, with which we come into contact in everyday life. It is these which cause oxygen to support life, nitrogen to allow it to stifle, and chlorine to deliberately destroy it.

Thus the study of the characteristic x-rays has enabled us to define regions of the atom to which various properties are assigned. In their interior, from which the characteristic x-rays come, we detect a stabilized region which persists unchanged as the atom undergoes various chemical combinations. I hope that in these few moments at my disposal I have succeeded in giving you a glimpse, at least, of what x-rays can tell the scientist about atoms.

ANCIENT FISH ADMIRERS

By Dr. S. W. FROST
THE PENNSYLVANIA STATE COLLEGE

THE lure of fish has a foundation almost as ancient as man himself. From the dawn of human history, the fish captivated man's eye and satisfied his palate. Primitive homes were built along the sea or near watercourses where fish abounded and could be easily obtained. So closely was man's early existence associated with this ichthyian that he learned to regard it with reverence and fear. We refer to the ancient worship of the Egyptians. The Nile not only furnished a staple food supply but replenished the land. This natural provider, and all connected with it, became an essential part of their belief. The fish was associated with the great genetrix Isis, the wife of Osiris and the mother of Hortus. According to an old legend, the tears of the goddess Isis fell into the Nile, caused the inundation of the river and thus brought the land wealth, which means nourishment. Although Isis has long been forgotten, her fertilizing tears survive. Even to-day every one in Egypt knows that the "divine drop" falls from heaven in June to bring about the rise of the Nile. It is no wonder that the fish was vitally impressed on the art of the Egyptians.

The earliest examples of the fish in art are found on stone seals from Ur. More than four thousand years before Christ, numerous intaglios were found, many of them inscribed with fish or fishermen. The fish has been found on the early button-like seals which antedate the beads and cylindrical seals of Babylonia. Another early example is a slate palette, in the form of a fish, discovered in the ruins of Nagada prior to 3000 B.C.

The fish occurs on numerous seascapes as incidental decorations, usually in the rippled waters. Bas-reliefs and paintings show that the ancient Egyptian used all known methods of catching fish —spearing with a harpoon, fishing with a line, setting nets and traps. A relief on the tomb of Gemneka, the VI dynasty, shows fishermen bringing in their day's catch. They carry their fish on sticks over their shoulders, in slings on their arms and in their hands. A Medum painting depicts two fishermen with a large fish suspended from a staff supported on their shoulders. A painting from Nakht and another from the tomb of Khnumhotpû at Beni-Hasan show fishermen using harpoons. A bas-relief in the mortuary chapel of the "Royal Companion" Tiy at Sakkâra illustrates four men pulling in a heavy net. A relief from the tomb of Ti shows a number of men fishing with a trap. Two of the men are lifting the trap, while others appear ready to take the fish. On a relief at Koyunjik is seen a Kufu laden with stone and manned by a crew of four. Behind the Kufu a fisherman sits astride an inflated skin with a fish basket attached to his neck.

The Egyptians, Babylonians, Phoenicians and Assyrians had their fish gods and goddesses. The Assyrian Ea, of the Nineveh tablets, is an example of a deity half man and half fish. Although this sort of merman deity had its origin in Asia, it found its way to Ireland and was eventually canonized as St. Darerea. The fish god Anou or Dagon, a native Semitic deity, was adopted by the Philistines after their settlement in Canaan. This god is figured on an Assyrian bas-relief from Nimrûd and is also figured on a Chalcedonian coin, which is inscribed with a star above, a winged

MOTIF FROM PHOENICIAN POTTERY
(AFTER PERROT AND CHIPIEZ).

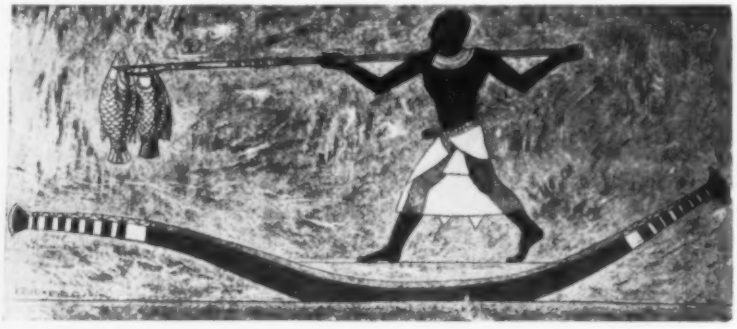
EGYPTIAN SLATE PALETTE
FROM NAGADA, 4000 B. C. (AFTER CHILDE).

figure to the left and the fish god to the right. The Babylonian fish god, Oannes, symbolized fertility. It is thought to be identified with the Assyrian Ea. A copy of this god occurs on a bronze bell now in the British Museum. Perrot and Chipiez figure a bronze plaque of questionable origin, but probably from Asia Minor. On this plaque two fish gods, "Oannes," are working over the dead. The chief figure is the goddess Allāt, passing through the nether region in her bark. Nergal, the god of Hades, peers over the top of the plaque. The Persian fish god "Iannes" or "Euahanes" is also identified with Ea and is supposed to dwell in the Persian Gulf (Erythraean Sea) rising out of the water in the daytime and furnishing mankind with instructions in writing. Two fish-like Deities of the Chaldeans may be seen on an intaglio in the British Museum.

Western Asia contributes many early examples of the fish motif. It is found on prehistoric painted pottery from Nal, Baluchistan, and is represented in the script of the Indus Valley prior to 3500 B.C. In India the fish is one of the avatars of Vishnu which saved the progenitor of the human race, Manu, from the flood. A typical Assyrian scene, taken from the palace of Khorsabad, shows workmen transporting wood across a stream in boats with numerous fish, crabs and animals swimming about in the water. An early Chaldean terra-cotta tablet shows a native carrying a fish. The fish is also found on one of the boundary stones of Nebuchadnezzar on the upper Nippur River.

The culture of ancient Crete reveals many representations of the fish. The flying fish fresco from Phylakopi, Melos, is one of the best-known examples. Cretan seals and pottery as early as 900 B.C. exhibit numerous examples of fish patterns. Mycenaean and Cretan fish script resemble superficially Egyptian hieroglyphs. The octopus motif is also found on Cretan pottery of the Minoan period especially from Palaikastro.

The art of Cyprus, like all other countries bordering the Mediterranean, abounds with examples of the fish motif.



FISHING WITH HARPOON, FROM TOMB KHNUMHOTPU
(AFTER MASPERO)

ANCIENT FISH FIGURES

(*Top*) CAT EATING FISH, FROM TOMB OF NAHKT, EGYPT (AFTER WEIGALL). (*Lower left*) PAIR OF FISH FROM UR, DATING ABOUT 2300 B.C. UNIVERSITY MUSEUM, PHILADELPHIA. (*Lower right*) TERRA-COTTA TABLET SHOWING CHALDEAN CARRYING A FISH (AFTER MASPERO).

FISH-NET PATTERN ON COILED BASKET OF THE THOMPSON INDIANS (AFTER BOAS).

It occurs especially on ancient seals and pottery. Dolphins were popular on bas-reliefs. A silver bowl from Solgoi, decorated with an incised fish, is worthy of special mention.

The fish was commonly used in the art of Russia and Siberia. This is especially true of earthenware from Ukraine. It is also found in the paper patterns of the Amur tribes.

The motif occurs frequently in the art of China and Japan and usually in realistic form. It is found on numerous netsukes, inros, tsubas, pottery and screens. The carp, known as the yu, is the species most often figured. This was chosen as the symbol of vigor, endurance, perseverance and power because to reach the headwaters of the stream to spawn, it had to leap the cataracts and falls. A beautiful painting, "Carp ascending a stream," has been executed by Kersai. The taid, a species of bream, is also used considerably in Japanese art. It is the attribute of Ebisii, one of the seven gods of happiness. Sesshō has immortalized this god in an excellent painting, "Ebisii the Fisherman." Paintings of the fish have been found as early as A.D. 618, but the finest work belongs to later generations.

An ancient Chinese cup of the Ming dynasty is decorated with two fish and a floral pattern. This bears the mark of the Chia Ching period, about 1522–66 B.C. Another ancient work of art is a goblet-shaped cup of white porcelain, with three fishes in red, under the glaze. This beautiful piece is figured in color by Hobson, "Chinese art." It belongs to the Ming dynasty and bears the mark of the Hsuan Te period, about 1426–35 B.C.

The legend of Gyoran Kwannona, daughter of King Miao To Houang, had its influence on Japanese art. She lived about 2577 B.C. and entered a monastery where she was finally directed by Buddha to retire to the island of Puto.

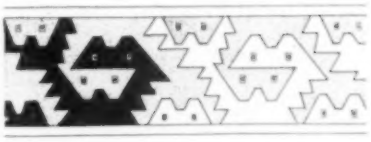
There she remained for nine years and established many monasteries. She is frequently figured carrying baskets of fish, a sort of saint.

The fish motif does not occur in Greek art until a later date. Among a collection of Mycenaean painted pottery there is a cup, decorated with fish and swans, which dates about 900–600 B.C. Other vessels show the octopus motif.

Old Greek coins were frequently inscribed with fish. Dolphins were used commonly during the third and fourth centuries preceding the birth of Christ, but the fish appears to be less common. A coin from Agrigentum dated 431–437 B.C. bears on the reverse a sea perch, a crab and a shell. The crab was the badge of Agrigentum and held a prominent place as the coin type of the city. This coin was used for a period of six or seven years just preceding the capture of Agrigentum by the Carthaginians in 400 B.C. The obverse of this coin bears an eagle tearing a hare that lies on the seashore. A coin from Cyzicus, dated 700–400 B.C., is inscribed with a tunny fish with fillets on each side. A silver coin from Gades, under Roman rule, has a head on the obverse and a fish on the reverse.

The fish is a familiar figure on old maps and has been used by astronomers for centuries. Aratus, 315–245 B.C., enumerates forty-four constellations, and among them is Pisces. Pisces fills the twelfth sign of the zodiac and is represented by two fishes tied together by their tails. In the Greek legend, Aphrodite and Eros, while on the banks of the Euphrates, were surprised by Typhon and sought safety by jumping into the water, where they were changed into two fishes. This is probably an adoption of an earlier Egyptian tale.

The fish was an early symbol of Christ in primitive and medieval art. The origin is to be found in the initial letters of the names of the titles of Jesus in Greek; Jesus Christ, Son of God, and Saviour,

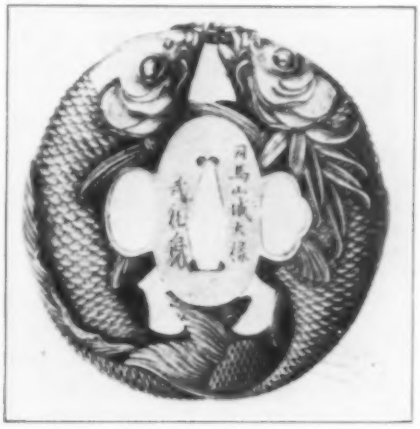


INTERLOCKED FISH PATTERN
FROM PERUVIAN FABRIC (AFTER CRAWFORD).

which together spell ἰχθύς—"fish." Two fishes crossed in a circle is an old Good Friday Yoni symbol and is known as the *Tessera convivialis*. This symbol may be seen in the catacombs at Rome, apparently a secret sign of the persecuted Christians.

During the early centuries of the Christian era, when man first ventured forth upon the briny deep, the fish became a fearsome monster in the minds of men, with many grotesque forms that lurked in the deep waters ready to seize the unfortunate navigators. Albertus Magnus, in his "Thierbuch," 1545, figures many of these monsters of the sea. Erinus and Zedrosus are two of particular interest of the fish type with heads of other animals.

The fish has been worked in a great many different kinds of materials. It is carved in ivory, especially in Africa, Japan and Alaska. It is moulded in



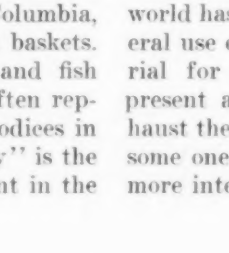
JAPANESE TSUBA OF OTSUKI SCHOOL
(AFTER GUNSAULUS).

copper, iron, gold and even in lead. A hanging lead cistern of the seventeenth century, England, is decorated with a dolphin. The fish is frequently used as a mark on porcelain and pottery from Germany, China, Switzerland, Venice, Holland and probably elsewhere. The printer's mark of the Aldi of Venice is an anchor with a fish twined about and bearing the letters A. L.

The fish also assumes a prominent part in heraldry and totemism, a discussion which we can not enter here.

It plays an important part in the art of the American Indian. In the Northwest, it is carved in wood and is frequently seen on totem poles. The seulpin swallowing a fish is a common motif of the Kwakiutl. In British Columbia, it occurs chiefly as a design on baskets. The spear, fish-hook, fish-net and fish backbone are the motifs most often represented. It was used on the codices in Mayan art. The word fish "cay" is the sign used on the original element in the Katun glyph which expressed the concept 20. In Guiana, the fish is generally found on baskets. The Merokot is represented by a highly conventionalized pattern. In Brazil, the fish is represented by a triangle. Sometimes fish scales are indicated by hexagonal figures. The fish reaches its perfection in the conventionalized art of Peru. It is a common motif on fabrics and invariably the pattern consists of two fishes, turned in opposite directions, making the "interlocked fish design." It is also incised on pottery or moulded into the form of a fish. The octopus is likewise a common design in Peru.

The simple form of the fish and its universal abundance throughout the world has contributed largely to the general use of this motif in art. The material for study is unlimited, and the present article does not pretend to exhaust the subject. It may serve to guide some one who cares to pursue the motif more intensely.



MOTIF FROM MIMBRES POTTERY (AFTER COSGROVE). MANY OTHER BEAUTIFUL FISH PATTERNS HAVE BEEN FOUND ON POTTERY FROM THE SWARTZ RUINS.

THE PROGRESS OF SCIENCE

IN MEMORIAM: WILLIAM HENRY WELCH (1850–1934)

THE death of Dr. Welch, on April 30, leaves a distinct void, not only in the American medical profession, of which he was easily the topmost figure; but, particularly in those wide fields of public hygiene and social welfare to which he devoted most of his later life. His passing, after a year's illness in the Johns Hopkins Hospital, was peaceful, unconscious, hence a fitting close to a life so wonderfully variegated, of such substantial accomplishment and such exclusive devotion to altruistic aims. In capacity for sheer enjoyment of existence, he was like unto the English physician of whom Dr. Johnson observed: "Dr. Mead lived more in the broad sunshine of life than any man." In the serene, cheerful, stoical fortitude with which he weathered the pains and tediums of his last illness, Dr. Welch was like the well-disciplined soldier, the least of whose virtues is "never to complain."

Coming of a long line of New England physicians, imbued from boyhood up with the essential atmosphere of medicine, it was but natural that Welch should follow the colonial tradition by fitting himself for the family profession at Columbia after his graduation from Yale (1870). Three years of postgraduate work in Europe under such masters as Carl Ludwig and Cohnheim, memorable contacts with such rising stars as Koch and Ehrlich, gave him a broad foundation in scientific medicine, such as few, if any, Americans of equal enterprise had acquired in his time. Back in New York, he supported himself by coaching medical students, later by medical practise, in connection with his chair of pathology in Bellevue Hospital Medical College (1879–84), where he established our first pathological laboratory. But his real future had already been decided. Billings, who planned the Johns Hopkins Hospital, and Cohnheim had already recommended Welch for the prospective Baltimore chair, whence his appointment to the Baxley professorship of pathology (1884) became a foregone conclusion. Before settling in the new environment, Welch spent another year of intensive laboratory training in Europe and may be said to have brought the newer bacteriology (of the Koch tradition) to the United States. With the opening of the Johns Hopkins Hospital (1889), he acquired adequate laboratory facilities and had already become widely known as the outstanding teacher and investigator of his disciplines in the country. In Cohnheim's laboratory, he had already made his mark through an original investigation of pulmonary œdema (1875). Important studies on glomerulo-nephritis, thrombosis and the pathology of fever followed. In 1891, he discovered the two pathogenic bacteria with which his name is best associated, *viz.*, the *bacillus aërogenes*, now known as *bacillus Welchii*, which activates gas-gangrene in wounds, and the staphylococcus which infects the edges of wounds from the skin. The importance of the Welch bacillus came to a focus on the Western Front, where the rotary motion of the projectile in gunshot wounds created an ideal pulpy culture medium for gas infection; while the significance of the *Staphylococcus epidermidis albus* as a source of wound infection in the sterilizable field of operation had long since been recognized in the surgical clinic. In connection with Dr. Welch's distinguished military career during the world war, it was not without reason, then, that General MacArthur, the Chief of Staff, requested that his body be buried as a national figure in the National Cemetery, at Arlington, under the aegis of the Army he had served so well.

Associated with Welch in these impor-

(From a painting by Thomas C. Corner, University Club, Baltimore, Md.)
WILLIAM HENRY WELCH

tant findings were two of his most brilliant pupils, Simon Flexner, who also collaborated with him in a pioneer investigation of the toxins of diphtheria (1891), and Nuttall. With a terminal study of the many morbid conditions activated by the gas bacillus (1900), Welch's laboratory period came to an end. In his second period, he was to live forward through and by his pupils; a long and impressive list, from Gorgas, in the Bellevue period, to Councilman, Thayer, MacCallum, Whipple, Blumer, Cullen, Opie, Winternitz, Abbott, Whitridge Williams, Bloodgood, Carroll, Lazear and Walter Reed. Through the work of some of these men, Welch "*hat Schule gemacht.*" Their devotion to the master was that of a group of loyal regimental adjutants to their commanding officer.

Welch's association with Osler, Halsted and Kelly in the development of the Johns Hopkins Medical School is commemorated in the Sargent painting. Osler brought in the great English tradition of bedside medicine; Welch and Halsted the Germanic program of laboratory and university clinic; Kelly the skill and enterprise of the self-helping surgeon of the pioneer American tradition, with a trace of the physician-naturalist, of the type of Conrad Gesner, Linnaeus or Johannes Müller. The teamwork of these four men and their pupil-associates made the Johns Hopkins the most efficient and productive medical school in the country. When Welch came to Baltimore, one of his Bellevue associates observed: "You may become a connoisseur of terrapin and madeira, but as a pathologist—good-bye!" As he approached his third period, that of activation and national leadership in medicine and international hygiene, Welch had long been in request everywhere as the engaging diner-out, the witty *raconteur*, the experienced presiding officer at medical meetings and other state occasions. As a prime-mover of American medicine, he was the natural, lineal successor of Billings, Weir Mitchell and Jacobi, whose leadership had been tacitly recognized, in turn, and never disputed. Welch's leadership became national and international at the outbreak of the world war and in connection with his services to the government. But for this interruption, his presidency of the National Academy of Sciences (1913–16) might have been made "perpetual," had he chosen, as with Fontenelle and Flourens in France. Welch's services to medical education in China and similar contacts in Europe made him more and more of an international figure. Upon his retirement from his chair of pathology (1916) came the School of Hygiene and Public Health, which he directed for a decade (1916–26); followed by two sabbatical years in Europe, spent in collecting books for the Welch Medical Library, then building. Here he found himself in harness again as professor of the history of medicine and director of the Institute, in which his successor, Professor Sigerist, has made such a brilliant record. Thus Welch was leader, prime-mover and activator to the last. Always an omnivorous reader, his declining years, as in Osler's case, were devoted to the love of books.

As he approached the scriptural span, Dr. Welch began to age perceptibly; but once he got his second wind, he grew younger with each succeeding year. Old friends, who heard his charming Californian reminiscences in 1930, declared him younger than ever before. Endowed with phenomenal vitality or strength of mind and body, extraordinary breadth of vision and a singular tenacity of memory and opinion, his nature was genial, lovable, attractive, receptive and hospitable to a fault. In any group-photograph of scientific men, his short, sturdy, thickset figure stands out, like some survival or evocation of a great past. His life of 84 years was rich and varied. In succession, we find him teaching Greek and Latin for a living

at Norwich; intimate and fellow student of the coming leaders of German medicine; the favorite physician of actors, actresses and detectives in New York City; the leading citizen of Baltimore and Maryland; a prominent adviser of the Rockefeller, Carnegie and Milbank Foundations; a major, colonel and brigadier general in the Army; eating through innumerable course dinners which would have killed any other man of his physical conformation; hoaxing Osler; being photographed with Mary Pickford; crashing through breakers at Atlantic City; laughing uproariously at the burlesque of himself in the students' "Pithotomy"; spending the night in Turkish bath establishments to hide away from importunate visitors; a maker *in posse* of scientific medicine in China and recipient of the most unique birthday honors ever accorded. His eightieth birthday was simultaneously celebrated in all the larger scientific centers of the world; yet he modestly waived the distinction as belonging properly to the profession he represented.

The likeness of Dr. Welch here reproduced, from the oil-painting by Thomas C. Corner (University Club, Baltimore), shows him in his prime and at his best. Here we have the massive head and brow of the essential high priest of knowledge; the huge, ventripotent frame of the epicure and lavish dispenser of hospitality; the keen, withal benevolent gaze of the intimate adviser of great financier-philanthropists. The three stages of Dr. Welch's life, the period, just ended, of unstinted endowment of scientific research, are all epitomized in this portrait. As Senator Walcott has intimated, Dr. Welch was a kind of Buddha, consecrated exclusively to the intellectual life and to altruistic pursuits; yet one to whom nothing human was alien. But about him there was nothing of the *vieux bonze*, the self-appointed bishop *in partibus*. His sly twinkle, his omnipresent elfin humor precluded any assumption of self-reference. Like the Priest of Nemi, in Renan's drama, he was one of those advanced liberals, who seemed, at whiles, to sell out his fellow countrymen through exaggerated esteem for foreign culture and thinking too far in advance of his time. If he was sometimes beguiled by self-seeking parasites, to the detriment, sometimes the disgust of his faithful coadjutors, it was but an obvious defect of his great qualities. The rest is a simple case of Newton's Third Law of Motion. Unless the civilized world relapses into barbarism, such steadfast devotion to altruistic aims, such broad-visioned love of his fellow men, can not fail of lasting recognition in the end. Fifty years ago, Dr. Welch affirmed that not sanitation but "nothing short of a social revolution" will alleviate the misery of the poor and unfortunate. Some such revolution is now in process all over the world. In some happier, less chaotic period than ours, Welch will come into his assured position as one of our greatest national figures and benefactors, *pia anima in pace*.

F. H. GARRISON

THE SEVENTY-FIRST ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences held its seventy-first annual meeting on April 23, 24 and 25 at the academy building in Washington, D. C. At this season of the year Washington is especially beautiful; the Japanese cherry trees are in full bloom, the shrubs in blossom, and the trees in nearly full leaf. This feature, together with the fact that several other scientific societies hold meetings directly after the academy sessions, makes Washington attractive to scientists and assures good attendance at the meetings, even though hotel accommodations may be difficult to secure.

The papers on the scientific program

DR. NORBERT WIENER
PROFESSOR OF MATHEMATICS
THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROFESSOR HARRY S. VANDIVER
ASSOCIATE PROFESSOR OF MATHEMATICS
THE UNIVERSITY OF TEXAS

numbered 55 and covered a wide range of subjects. Their distribution among the fields of science was the following: Mathematics 1; astronomy 5; physics 13; chemistry 3; geology 8; meteorology 2; botany 7; biology 3; zoology 1; physiology 3; pathology 2; medicine 3; genetics 1; psychology 1; anthropology 1; general science 1. Forty-one papers were presented by members of the academy and thirteen by non-members. The large number of communications in physics reflects the intense activity in this field of science at the present time. Sir Arthur Eddington, foreign associate of the academy, presented a paper entitled "Unification of Relativity Theory and Quantum Theory." Drs. Stebbins and Whitford described the photoelectric amplifier and its application to the photometry of faint stars and nebulae. Drs. Millikan and A. H. Compton reported on recent results obtained in the field of cosmic rays. Drs. Lauritsen and Crane described experiments on transmutations by artificially accelerated particles, the accelerations being produced by use of the high potential x-ray tube developed at the California Institute of Technology. Drs. A. H. Compton and Wollan deduced the "appearance" of atoms of helium, neon and argon, as observed by x-rays, from the image obtained by photographing a rotating template whose shape was calculated by a mathematical transformation of measured values of the x-rays scattered by the respective gases. Dr. H. Fletcher analyzed loudness and pitch of musical tones and their relation to intensity and frequency; Dr. C. E. Seashore approached the subject from a slightly different view-point and spoke on the quality of sound. By invitation, Dr. B. F. J. Schonland exhibited photographs of lightning discharges and their development, as taken by the special camera devised by C. V. Boys. Drs. Osterhout and Hill described experiments on cells of the fresh-water plant *Nitella*, in which stimuli were found to be transmitted by

DR. ERNEST O. LAWRENCE
PROFESSOR OF PHYSICS
THE UNIVERSITY OF CALIFORNIA

DR. VANNEVAR BUSH
DEAN OF THE ENGINEERING SCHOOL
THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DR. DENNIS ROBT. HOAGLAND
PROFESSOR OF CHEMISTRY
THE UNIVERSITY OF CALIFORNIA

DR. JAMES F. NORRIS
PROFESSOR OF ORGANIC CHEMISTRY AND DIRECTOR
OF THE RESEARCH LABORATORY
THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

negative variations which travel along the cell, just as in muscle and nerve. Sufficient exposure of *Nitella* cells to distilled water abolishes the characteristic variations when stimulated by an electric current. The simplest explanation is that an organic substance is dissolved out of the surface by distilled water. It seems possible that other cases of anesthesia may be due to the fact that substances are removed from the cell. Dr. Earl H. Myers exhibited an interesting motion picture showing the life history of the foraminifer *Patellina corrugata*.

DR. CHARLES PALACHE
PROFESSOR OF MINERALOGY
HARVARD UNIVERSITY

DR. JOHN H. NORTHROP
MEMBER, THE ROCKEFELLE INSTITUTE FOR MEDICAL RESEARCH

Drs. Henderson, Oughterson, Greenberg and Searle reported on muscle tonus, itself controlled from the central nervous system and considerably influenced by the respiratory center, as the basic factor determining the amount of metabolism and the correlated volumes of the circulation and respiration and as an element of prime importance in the venopressor mechanism. Experiments described by Dr. Simon Flexner showed clearly that the source and mode of infection in poliomyelitis is through the nasal passages and that the virus is confined to the human host and passes from individual to individual in the secretions of the nose and throat. Dr. Douglas Johnson concluded from physiographic evidence that the supposed meteorite scars of South Carolina represent former lake basins surrounded by rims of windblown sand, rather than meteor impact forms. Dr. J. C. Merriam emphasized, in a paper on "Science and Conservation," the responsibility which science has for making clear the present and future significance of materials needed for scientific investigation, for intellectual appreciation and for economic use.

On Monday evening Dr. Edwin Hubble delivered the evening lecture and presented a most interesting statement on the "Realm of the Nebulae." The attendance at the lecture was 510.

The average attendance at the sessions in the Auditorium was 450 and in the

DR. HERBERT S. GASSER
PROFESSOR OF PHYSIOLOGY
CORNELL UNIVERSITY MEDICAL COLLEGE

DR. E. NEWTON HARVEY
PROFESSOR OF PHYSIOLOGY
PRINCETON UNIVERSITY

Lecture Room, 160. One hundred and twenty-seven academy members and two foreign associates registered at the meeting. At the annual dinner on Tuesday evening President Campbell delivered, at the request of the local committee, a brief address on the status of academy activities at the present time. This was followed by the presentation of five medals:

Agassiz Medal. Awarded to Bjorn Helland-Hansen, of the Geofysiske Institut, Bergen, Norway, in recognition of his work in physical

DR. SEWALL WRIGHT
PROFESSOR OF ZOOLOGY
THE UNIVERSITY OF CHICAGO

oceanography, especially for his contributions to knowledge of the dynamic circulation of the ocean. The presentation address was made by Dr. H. B. Bigelow. In the absence of Dr. Helland-Hansen the medal was received for him by The Honorable Halvard H. Bachke, Minister from Norway.

Elliot Medal and Honorarium of $200 for 1930. Awarded to George Ellett Coghill, Wistar Institute of Anatomy and Biology, Philadelphia, Pennsylvania, in recognition of his work: "Correlated Anatomical and Physiological Studies of the Growth of the Nervous System in Amphibia." The presentation address was made by Dr. Ross G. Harrison.

Elliot Medal and Honorarium of $200 for 1931. Awarded to Davidson Black (since deceased). Dr. Black, a native of Canada, was professor of anatomy at the Peiping Union Medical College, Peking, China, at the time of his death on March 15, 1934. The award was made in recognition of his work on an adolescent skull of *Sinanthropus Pekinensis* in comparison with an adult skull of the same species and with other hominid skulls, recent and fossil. The presentation address was made by Dr. Henry Fairfield Osborn. The medal was received by Dr. Frank Dawson Adams, foreign associate of the academy, from Canada, on behalf of the legal representative of Dr. Black.

DR. THOMAS M. RIVERS

MEMBER, THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

Public Welfare Medal. Awarded to David Fairchild, formerly of the U. S. Department of Agriculture, Washington, D. C., for his exceptional accomplishments in the development and promotion of plant exploration and the introduction of new plants, shrubs and trees into the United States. The presentation address was made by Dr. Henry H. Donaldson. The medal was received by Dr. K. A. Ryerson, chief of the Bureau of Plant Industry of the U. S. Department of Agriculture on behalf of Dr. Fairchild, who was unable to be present.

Charles Doolittle Walcott Medal and Honorarium of $1,350. Awarded to David White, of the U. S. Geological Survey, Washington,

DR. ELVIN C. STAKMAN

PROFESSOR OF PLANT PATHOLOGY
THE UNIVERSITY OF MINNESOTA

DR. EDWARD SAPIR

PROFESSOR OF ANTHROPOLOGY AND LINGUISTICS
YALE UNIVERSITY

D. C., in recognition of his work, published and unpublished, on the Precambrian algae life of the Grand Canyon of Arizona. The presentation address was made by Dr. Charles Schuchert.

At the business meeting held on Wednesday, April 25, the following officers and members were elected:

Foreign Secretary: Dr. T. H. Morgan, of the California Institute of Technology, Pasadena, California, for a period of four years, commencing July 1, 1934.

New Members of the Council of the Academy: H. S. Jennings, of the Johns Hopkins University, Baltimore, Maryland, and Roger Adams, of the University of Illinois, Urbana, Illinois, for a term of three years, commencing July 1, 1934.

New Foreign Associates: V. F. K. Bjerknes, of the Physical Institute of the University of Oslo, Oslo, Norway, and Robert Robinson, of the University of Oxford, Oxford, England.

Fourteen men were elected to membership. Their photographs accompany this article.

The present membership of the academy is 285, with a membership limit of 300; the number of foreign associates is 45 with a limit of 50.

The autumn meeting of the academy will be held this year on November 19, 20 and 21 at Cleveland, Ohio.

F. E. WRIGHT,
Home Secretary

THE JUNE STRATOSPHERE BALLOON FLIGHT

PLANS are being formulated for a balloon ascent into the stratosphere early in June, under the joint auspices of the National Geographic Society and the United States Army Air Corps. Major William E. Kepner, an outstanding balloon pilot, and Captain Albert W. Stevens, aerial photographer, both of the United States Army Air Corps, will participate in the flight.

The ascent is being made to obtain information concerning upper regions of the atmosphere. There is no desire to perform a "stunt" or to establish an altitude record for its own sake. A large balloon will be used so that two men and a large number of scientific instruments and devices can be taken to the highest practicable altitude.

The specific projects to be carried out include:

Temperature and barometric measurements from the earth to the "ceiling" of the flight; a check on barometer measurements of altitude by optical methods; a camera of accurately determined focal length, mounted in the bottom of the gondola, to photograph the earth, making it possible through subsequent map studies to compile more accurate altitude tables than those now in use; bottling of air samples at various altitudes, samples being brought to earth and analyzed for gas composition and relative humidity; ascertainment of electrical condition of the atmosphere from the 5,000-foot level to the flight "ceiling"; recording cosmic ray intensity, penetration and direction of movement, at various levels; wind direction and velocity studies; measurement of solar radiation; photography of the solar spectrum; record of sky brightness;; oblique photography for distance, and test of actinic value of light, and secondary absorption by the atmosphere; effects of altitude on radio transmission; balloon navigation problems, particularly effects of "superheat" acquired by balloon and gondola.

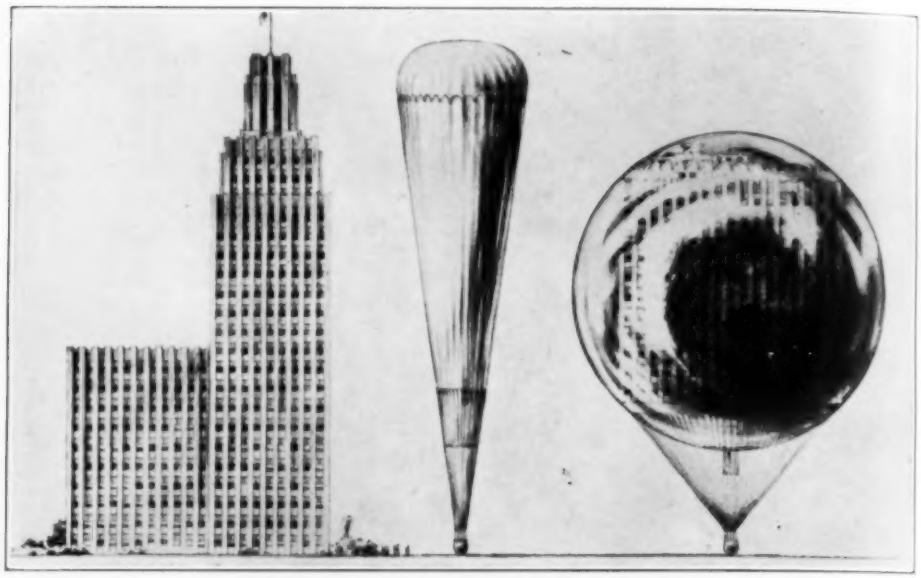
Other projects may be added if the time of the observers permits and if satisfactory methods can be worked out. Efforts are being made, for example, to devise satisfactory plans and equipment to ascertain the presence of ozone at high levels. The ozone in the upper air can not be determined from the air samples brought to earth, as the gas is unstable and will break down into ordinary oxygen.

Construction of the balloon is now well under way in the factory of the Goodyear-Zeppelin Corporation, Akron, Ohio. It is five times the size of the balloon used by Commander Settle and Major Fordney in November, 1933, and three and a half times the size of the Russian balloon which rose into the stratosphere in September, 1933.

Two and one third acres of cotton cloth are being used to build the bag; and it will contain, fully inflated, 3,000,000 cubic feet of gas. It will be about one thirteenth filled with hydro-

THE MEETING OF THE ADVISORY COMMITTEE OF SCIENTIFIC MEN

WHO ARE DIRECTING ARRANGEMENTS FOR THE STRATOSPHERE FLIGHT, HELD IN THE BOARD ROOM OF THE NATIONAL GEOGRAPHIC SOCIETY. MEMBERS FROM LEFT TO RIGHT ARE: (SEATED) DR. FREDERICK V. COVILLE, U. S. DEPARTMENT OF AGRICULTURE; MAJOR WILLIAM E. KEPNER, U. S. ARMY AIR CORPS; DR. LYMAN J. BRIGGS, *chairman*, DIRECTOR, U. S. BUREAU OF STANDARDS; CAPTAIN ALBERT W. STEVENS, U. S. ARMY AIR CORPS; DR. GILBERT H. GROSVENOR, PRESIDENT, NATIONAL GEOGRAPHIC SOCIETY, AND DR. CHARLES F. MARVIN, FORMERLY CHIEF, U. S. WEATHER BUREAU; (STANDING) DR. W. G. BROMBACHER, MR. E. R. WEAVER AND DR. F. L. MOHLER, OF THE U. S. BUREAU OF STANDARDS; MR. GEORGE W. HUTCHISON, SECRETARY, NATIONAL GEOGRAPHIC SOCIETY; CAPTAIN RAYMOND S. PATTON, DIRECTOR, U. S. COAST AND GEODETIC SURVEY; DR. FLOYD K. RICHTMYER, DEAN, GRADUATE SCHOOL, CORNELL UNIVERSITY, NATIONAL ACADEMY OF SCIENCES; DR. W. F. G. SWANN, DIRECTOR, BARTOL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE, SWARTHMORE, PA.



THE SIZE OF THE BALLOON

WHEN READY TO LEAVE THE GROUND THE BALLOON WILL HAVE THE SHAPE SHOWN IN THE CENTRAL FIGURE. IT WILL BE LESS THAN ONE TENTH FILLED WITH HYDROGEN, AS SPACE MUST BE LEFT FOR EXPANSION OF THE GAS IN THE UPPER AIR. WHEN THE BALLOON IS READY TO RISE, ITS TOP WILL BE 295 FEET ABOVE THE EARTH—HIGHER THAN THE 26-STORY OFFICE BUILDING SHOWN AT THE LEFT. AT THE TOP OF ITS FLIGHT (NEARLY 15 MILES ABOVE SEA-LEVEL) THE BALLOON WILL HAVE EXPANDED TO BECOME A SPHERE 180 FEET ACROSS. THE FIGURE AT THE RIGHT INDICATES THAT THE HUGE BALL WOULD THEN BE LARGE ENOUGH TO ENCLOSE AN 11-STORY CUBICAL BUILDING

gen when it leaves the ground. Room must be left for great expansion of the hydrogen in the upper air where pressure is light.

The gondola will be an airtight hollow ball of Dow metal, a light magnesium alloy, 8 feet, 4 inches (100 inches) in diameter. The shell of the globe will be slightly less than one fifth of an inch thick. Inside, vertical tubular posts will strengthen the shell and maintain the globular shape against the strains created by the suspension and the heavy load of instruments and ballast. In the lower part of the gondola a floor of metal 60 inches in diameter will be constructed for the convenience of the two operators.

The flight will take place near dawn, as early in June as weather conditions will permit. Complete weather information will be furnished by the U. S. Weather Bureau, and the flight will be undertaken only when there is probability of slow air movement at the surface of the earth, and freedom from clouds and haze between the earth and the stratosphere.

The point of take-off will be somewhere in the western United States near the eastern edge of the Rocky Mountains. It is estimated that the balloon will drift about 600 miles to the east, southeast or northeast before dusk. With the take-off near the Rockies the landing should be made in the open country, permitting salvage of the bag.

If the flight in June is successful and the bag can be salvaged in good condition, a second flight will probably be made in September with the same personnel from the same locality, in order to check observations under similar conditions.

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